VOLUME TWO

AUTOMATIC TELEPHONE SYSTEMS

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AUTOMATIC TELEPHONE SYSTEMS

By WILLIAM AITKEN, M.I.E.E., A.Am.I.E.E.

VOLUME TWO

AUXILIARY SERVICES AND PRIVATE AND BRANCH EXCHANGES

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PREFACE

THE delay in issuing the second part of this work is regretted.

This has been caused by the very intricate nature of the work, on which only draughtsmen of the highest qualifications could be employed. The delay is also partly due to some of the important systems not being sufficiently advanced for publication.

This, with the great accumulation of interesting matter on large multi-office systems, has made it necessary to issue the remaining matter in two volumes. It is hoped that Vol. III. will follow Vol. II. with only a very brief interval.

One firm uses an arrangement of diagrams essentially different from all the others. In Vol. I. these were converted to the generally accepted form. This has not found favour. In the case of diagrams, Figs. 85 to 90, both forms are shown on the same sheet, so that readers can form their own opinion regarding their respective merits. In one or two cases no conversion has been made. "Bus-routing" of circuits is applicable in both cases.

The author desires to express his indebtedness and thanks to Col. T. F. Purves, O.B.E., M.I.E.E., Engineer-in-Chief, G.P.O., and the officials of the different companies whose work is described, for valuable assistance rendered.

LONDON, June 1923.

W. AITKEN.

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OUTLINE OF CONTENTS OF VOLUMES I. AND III.

VOLUME I.

THE STATE OF THE ART.—Some definitions—First principles.

DIAL IMPULSE SENDERS.—Telephone instruments.

STROWGER SYSTEM (A. T. M. Co.: A. E. Co.).—Switching apparatus—Plunger and rotary line switches—Vertical and rotary selectors and connectors, and their circuits—Rotary connectors, repeaters, trunk offering, apparatus and circuits—Testing apparatus.

Siemens' system—Rotary line switches—Vertical and Rotary selectors and connectors—Discriminators—Fault and group alarm, testing, trunk offering, apparatus and circuits.

MACHINE-SWITCHING SYSTEMS (W. E. Co.).—Rotary switches—Continuous drive—Line finders—200-line selectors—Sequence switches—Registers—Apparatus and circuits—Revertive impulse control—A 100,000-line Rotary system—Lamp call-indicator system.

Panel system — 500-line switches, construction and circuits — Horizontal-type sequence switch—Line-finders—Metering, Lorimer system—Apparatus and circuits.

AMERICAN AUTOMATIC TELEPHONE CO.'S SYSTEM.

RELAY SYSTEM.—Apparatus and circuits.

COVENTRY AUTOMATIC TELEPHONE SYSTEM.—Apparatus and circuits.

STANDARD TERMS AND DEFINITIONS.

VOLUME III.

AUTOMATIC SYSTEMS IN LARGE MULTI-OFFICE AREAS.—Increasing the capacity of standard switches—Switches with a plurality of sets of wipers—The Director system (A. T. M. Co.)—Access to large groups of trunks by standard switches—Secondary line switches in trunks, with repeaters—The panel system, with 500-line switches (W. E. Co.)—The Swedish Ericsson Company's system, with rotary and radial 500-line switches.

SEMI-AUTOMATIC SYSTEMS.—Working between manual and automatic offices (A. T. M. Co.)—Full automatic with control from a manual board (Siemens)—Junctions between manual and automatic offices—Keyboard senders—Call-indicator systems—Rotary-switch system (W. E. Co.)—Panel, 500-line switch system (W. E. Co.)—Central Control in Semi-automatic systems—Automanual system (C. A. T. Co.)—Traffic-distributor system (Siemens)—The Christensen automatic distributor—Unattended offices—Order-wire working.

METERING OR REGISTERING TELEPHONE CALLS.—By reversed battery—By increase of current—Zone metering—Telephone unit—Cumulative metering.

TRUNK OR TOLL LINE WORKING.—Operating toll lines without operators (A. T. M. Co.)—High-frequency ringing—Phantom or superimposed working.

WIRING SCHEMES.—Multipling—Distributing and slipping—Overflow switches. Layout and wiring.

POWER PLANT.

TRAFFIC.

MISCELLANEOUS SYSTEMS.—British L. M. Ericsson automatic system, using cords and plugs—Rotary and radial switches with horizontally wired banks—By-path systems, etc., etc.

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LIST OF SECTIONS

SECT.
1 Equipment in Subscribers' Offices . . . 1
„ Extension Instruments. Wall Sockets and Plugs . . . 1
2 „ Simple Extensions . . . 4
3 „ Extension Line with Intermediate Switch . . . 11
4 „ Coin Boxes. On Direct and Party Lines . . . 16
5 „ „ Post Office Circuits . . . 18
6 „ „ Circuit with Tone Signal . . . 21
7 „ Sub-station Call Meter . . . 22
8 Party-Line Working . . . 27
9 „ Frequency Selecting Connector Circuit (A. T. M. Co.) . . . 27
10 „ Discriminating by the Selector (A. T. M. Co.) . . . 29
11 „ Frequency Selector (A. T. M. Co.) . . . 31
12 „ Reverting Call Switch (A. T. M. Co.) . . . 32
13 „ „ „ (W. E. Co.) . . . 34
14 „ Lines multipled over a Plurality of Groups of Connectors . . . 37
15 „ Lock-out and Re-ringing Circuit . . . 38
16 „ Selective signalling . . . 40
17 Small Switchboards. Up to 25 Lines. (Post Office P.B.X.) . . . 49
18 „ „ 25 to 60 Lines „ „ . . . 52
19 „ „ 10-line Cordless „ „ . . . 56
20 Branch and other Small Offices. Typical Arrangements . . . 60
21 „ British Post Office and Traffic Facilities . . . 66
22 Automatic District Offices in a Manual System . . . 68
23 Main and District Office Alarm Apparatus . . . 71
24 Branch Offices. Full and Restricted Service . . . 73
25 „ With Direct and Party Lines . . . 75
26 „ Local Connections without utilising Trunk to Central . . . 77
27 „ „ Another circuit . . . 81
28 „ „ „ with Rotary Switch . . . 83
29 „ Connector operated from Selector or Toll Operator . . . 86
30 „ Access to a Group of Trunks on a Plurality of Levels (A. T. M. Co.) . . . 88
31 „ Final Selectors for Individual Lines and small P.B.X.'s and for large Groups of Trunks on a Plurality of Levels (Siemens) . . . 92
32 „ A Small All-relay Office (A. T. M. Co.) . . . 96
33 Private Automatic Installations in Works and the like . . . 99
34 „ A. T. M. Co.'s P.A.X. System . . . 101
35 „ „ Switches. Connector Circuit . . . 104
36 „ „ „ Selector Circuit . . . 107
37 „ „ „ 2-wire Repeater . . . 109
38 „ „ and Manual Service . . . 111
39 „ „ Special Services . . . 115
40 „ „ „ Code Calling . . . 118
41 „ „ „ „ using Selector Levels . . . 122
42 „ „ A modified Code-Calling Circuit . . . 124
43 „ „ Miscellaneous Services. Watchmen's. Fire Alarm. Interception. Secretary. Double Number Pick-up . . . 125
44 „ Siemens Autophone System. 100 lines . . . 131
45 „ „ „ „ 200 lines . . . 133
46 „ „ Power and Alarm Circuits . . . 135

LIST OF SECTIONS

SECT.

Private Automatic Installations in Works and the like. . . . [illegible]
47 „ 100-line Relay-link System (R. A. T. Co.) 147
48 „ Select-O-phone System. Pettigrew & Merriman 149
49 „ A Circuit of the Stevens' System 151
50 „ Couch System. Pr. Tele. and Elec. Co. 153
51 Village Automatic Exchange (Siemens) 158
52 „ Connector 161
53 „ Junction working 172
54 „ Common Apparatus 181
55 „ Routine Tester 184
56 „ Power Plant 187
57 Community Exchanges. Objects and Advantages (A. T. M. Co., A. E. Co.) 189
58 „ Types to meet Different Requirements 192
59 „ Connector 198
60 „ Automatic Voltage Regulation 203
61 „ Circuits for various Services

SUPPLEMENT TO VOL. I

62 British Post Office Dial No. 8 209
63 New Design of Wall and Table Telephone (A. T. M. Co., A. E. Co.) 213
64 „ with H.M.T. (Siemens) 215
65 An Impulse Equalising Device (A. T. M. Co.) 219
66 Condenser Device to repeat Impulses to Switches (Laidlaw) 222
67 An Impulse Converter (R. A. T. Co.) 225

LIST OF ILLUSTRATIONS

FIG. PAGE

Extension Line Working—

1 „ Wall Sockets and Plug (A. T. M. Co.) . . . 1
2 „ „ (Siemens) . . . 2
3 „ „ (W. E. Co.) . . . 3
4 „ Simple Extension (A. T. M. Co.) . . . 4
5 „ Table Instrument Circuit (A. T. M. Co.) . . . 5
6 „ Main Instrument with two extensions (Siemens) . . . 6
7 „ „ Wall Instrument (Siemens) . . . 6
8 „ „ Table Instrument (Siemens) . . . 7
9 „ „ Secrecy Switch (Siemens) . . . 8
10 „ Main Instrument and simple extension. Table Instrument (W. E. Co.) . . . 8
11 „ „ and two extensions (W. E. Co.) . . . 9
12 „ „ „ (W. E. Co.) . . . 10
13 „ A 4-way Switch . . . 11
13A „ Intermediate Switching Set (A. T. M. Co.) . . . 11
14 „ A Battery Indicator (Drum Type) (A. T. M. Co.) . . . 11
15 „ Post Office Circuit of Bell-set No. 4, with 3-position Switch . . . 12
16 „ „ „ with 4-position Switch . . . 13
17 „ Explanatory Circuit of above . . . 14

Coin Box—

18 „ Explanatory Circuits (A. T. M. Co.) . . . 16
19 „ Wall Instrument (A. T. M. Co.) . . . 18
20 „ Table Instrument (A. T. M. Co.) . . . 19
21 „ With Tone Signal (A. T. M. Co.) . . . 21

Sub-station Call-meter—

22 „ Wall Instrument (A. T. M. Co.) . . . 22
23 „ Table Instrument (A. T. M. Co.) . . . 23

Party Lines—

24 „ Frequency Selecting Connector (A. T. M. Co.) . . . 28
25 „ Discriminating by Selector (A. T. M. Co.) . . . 29
26 „ Frequency Selector (A. T. M. Co.) . . . 31
27 „ Reverting Call Switch (A. T. M. Co.) . . . 32
28 „ „ (W. E. Co.) . . . 35
29 „ P.O. Circuit for two parties . . . 37
30 „ Lock-out and re-ringing (A. T. M. Co.) . . . 39
31 „ Slow-acting alternating and D.C. relay (W. E. Co.) . . . 40
32 „ 4-party Selective ringing Circuit (W. E. Co.) . . . 41
33 „ Low-frequency Instrument Circuit (Leich) . . . 41
34 „ High Frequency Instrument Circuit (Leich) . . . 41
35 „ Harmonic Ringer (Dean) . . . 42
36 „ „ Details (Dean) . . . 42
37 „ „ Circuit (Dean) . . . 43
38 „ „ Converter (Dean) . . . 43
39 „ Frequency Meter (Hartmann-Kempf). Detail of Electro-magnet . . . 44
40 „ „ „ „ Detail of Reed . . . 44
41 „ „ „ „ „ Front View . . . 45

Sub-station Switchboards—

42 „ Up to 25 Lines capacity (Post Office) . . . 50
43 „ 25 to 60 Lines capacity (Post Office) . . . 53

FIG. PAGE

Sub-station Switchboards—
44 „ A Drop Indicator 54
45 „ An Eyeball Indicator (W. E. Co.) 54
46 „ 65-lines capacity (Post Office) 55
47 „ Cordless with Negative Clearing Signals (Post Office) 57
48 „ „ Positive Clearing Signals (Post Office) 58
Branch and other Sub-offices—
49 „ An Exchange System with Satellites 60
50 „ Typical Branch and other small Offices 61
51 „ „ Manual Working 63
52 „ Small Central and Mixed Services (Community) 64
53 „ A District Station through to a Manual Office. Circuit 68
54 „ Manual through to a District Station. Circuit 69
55 „ Transfer working of District Station. Circuit 70
56 „ Unattended District Office Trunking (A. T. M. Co.) 71
56A „ Branch Office Supervision at Main Office (A. T. M. Co.) 72
57 „ Branch Office with Service Discrimination (A. T. M. Co.) 73
58 „ With Direct and Party Lines. 300-line Connector (A. T. M. Co.) 75
59 „ Multi-office System. Lay out 77
60 „ System with Switching-Repeaters. Satellite Office 77
61 „ „ „ Main Office 77
62 „ Local Connections without utilising Trunks to Central 79
63 „ „ Alternative Method 82
64 „ „ using a Rotary Switch 84
65 A P.B.X. Connector accessible to Selectors and Operators (A. T. M. Co.) . . . 86
66 A Branch Office 1-digit Connector, giving access to Large Groups (A. T. M. Co.). . . 89
67 A Branch Office (Final Selector) Connector (Siemens) 93
68 „ For Individual Lines and Small Groups of Trunks (Siemens) . . Folder, *facing* 94
69 „ For Large Groups on a Plurality of Levels (Siemens) . . . . „ „ 94
70 P.A.X. An All-relay Small Office Circuit (A. T. M. Co.) 97
71 P.A.X. (Private Auto. Exchange) 100-lines (A. T. M. Co.) 99
72 „ Connector Circuit (A. T. M. Co.) 104
73 „ Selector Circuit (A. T. M. Co.) 107
74 B.A.X. (Branch Auto. Exchange) 2-wire Repeater (A. T. M. Co.) 109
75 „ Manual Working (A. T. M. Co.) 111
75A „ „ Cord Circuits (A. T. M. Co.) 112
P.A.X. and B.A.X.—
76 „ Special Services. Conference Circuit. 46 Volt (A. T. M. Co.) 115
76A „ „ „ 12 Volt (A. T. M. Co.) 115
77 „ „ „ Alternative (A. T. M. Co.) 116
78 „ „ Code Call (A. T. M. Co.) 119
79 „ „ „ Using Selector Level 123
80 „ „ „ A modification 125
81 „ „ Watchman's (A. T. M. Co.) 127
82 „ „ Fire Alarm (A. T. M. Co.) 128
83 „ „ Secretary's (A. T. M. Co.) 129
84 „ „ Double-number Pick-up (A. T. M. Co.) 129
85 P.A.X. 100-lines. Siemens Autophone No. 2. Circuit . . . .
86 „ „ „ Key diagram . . . .
87 „ Discriminator for 200 Lines. Siemens Autophone No. 2. Circuit . Folder, *facing* 134
88 „ „ Key Diagram . . . .
89 „ Control and Alarm Circuits. Siemens Autophone No. 2 . . . .
90 „ „ Key Diagram . . . .
91 „ Power Circuits. Siemens Autophone No. 2 135
92 „ 100-line No. 2 Autophone (Siemens). General view 136
93 „ Dynamotor for above 137
93A „ Dynamotor for Village Exchange 137
94 „ 50-line Relay System Lay-out (R. A. T. Co.) 142
95 „ 50-line Relay System Circuit (R. A. T. Co.) . . . . Folder, *facing* 146
96 „ „ Manual working with Main Office (R. A. T. Co.) 146
97 „ „ Trunk to C.B. Office (R. A. T. Co.) 146

LIST OF ILLUSTRATIONS

98 P.A.X. Select-O-Phone Circuit (Pettigrew & Merriman) . . . 147
99 „ „ Panel arrangement . . . 147
100 „ „ Instrument . . . 148
101 „ A Stevens' Circuit . . . 149
102 „ 100-point Dial. Couch System (Pr. Tele. and Elec. Co.) . . . 151
103 „ Selector, front view. Couch System (Pr. Tele. and Elec. Co.) . . . 151
104 „ „ rear view. Couch System (Pr. Tele. and Elec. Co.). . . . 151
105 „ Wall Instrument. Couch System (Pr. Tele. and Elec. Co.) . . . 151
Village Automatic Exchange (Siemens)—
106 „ 50-line Rack. Front . . . 154
107 „ „ „ Rear . . . 154
108 „ Connector (Final Selector) Circuit . . . Folder, *facing* [illegible]
109 „ Bothway C.B. Junction . . . 162
110 „ „ C.B.S. Junction . . . 165
111 „ „ Magneto Junction. Without Supervision . . . 166
112 „ „ „ With Supervision . . . 167
113 „ „ To Trunk Office . . . 168
114 „ Party-line Working (Siemens) . . . 169
115 „ Common Apparatus Circuit (Siemens) . . . Folder, *facing* 176
116 „ Junction Alarm Circuit (Siemens) . . . 178
117 „ Routine Testing Circuit (Siemens) . . . 181
118 „ Power Circuit (Siemens) . . . Folder, *facing* 186
119 „ Petrol-electric Generator (Siemens) . . . 184
120 „ Power Board. Front and Rear (Siemens) . . . 185
C.A.X. Community Automatic Exchange (A. T. M. Co.)—
121*a* „ Isolated Office Lay-out . . . 190
121*b* „ Tandem Office Lay-out . . . 190
121c „ Radial Type Lay-out . . . 190
121*d* „ Network Type Lay-out . . . 190
122 „ Connector Circuit . . . Folder, *facing* 196
123 „ Automatic Voltage Regulation . . . 198
123A „ Dynamotor . . . 199
124 „ Typical Circuits . . . Folder, *facing* 206

SUPPLEMENT TO VOL. I.

125 P.O. Standard Dial No. 8. Front View. . . . 209
126 „ Interior . . . 209
127 „ „ . . . 210
128 „ Section . . . 210
129 „ Parts . . . 211
130 „ Impulse Oscillograms . . . 212
131 New Design Wall Instruments (A. T. M. Co., A. E. Co.) . . . 213
132 „ Details . . . 214
133 New Design of Table Telephone (A. T. M. Co., A. E. Co.) . . . 214
134 „ Details . . . 214
135 New Design of Wall Telephone with H.M.T. (Siemens) . . . 215
136 New Design of Table Telephone with H.M.T. (Siemens) . . . 216
137 Circuit for above . . . 217
138 An Impulse Equalising Device. Circuit (A. T. M. Co.) . . . 220
139 Condenser Device to Repeat Impulses. Circuit (Laidlaw) . . . 222
140 An Impulse Converter. Circuit (R. A. T. Co.) . . . 225

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EXTENSION LINE WORKING

LINES WITH METERS AND COIN-BOXES

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Section 1

EQUIPMENT IN SUBSCRIBERS' OFFICES

These are sometimes spoken of as sub-station equipments. Impulse-dials are described in Sections 4 to 7, Vol. I., inclusive, and instruments and their circuits are described in Section 8. In the latter these are, however, shown in connection with direct lines only.

Extension Instruments.—Different types of service may be given to extension instruments. Two instruments may be in parallel on the same line; one only, however, should be fitted with a bell to receive calls, the second instrument being called on a separate bell and push circuit. A few circuits of standard arrangements follow.

Wall Sockets and Plugs.—Fig. 1 shows an arrangement for use on the A. T. M. Co.'s system. A plurality of wall sockets can be fitted, three being shown in the diagram. Each socket has one break contact, shown at *e*, and this contact is opened when a plug is inserted. A bell and condenser may be fitted at each socket, or at one socket only if all calls, when the plug is not in a socket, are to be received at one point only. All, of one station, must have the strap connection, *c*, joined across to put the bell in circuit. A plug is associated with one instrument which can be carried from point to point as required. It will be noticed that the contacts of the switches are in series, the wire then connecting to a common circuit

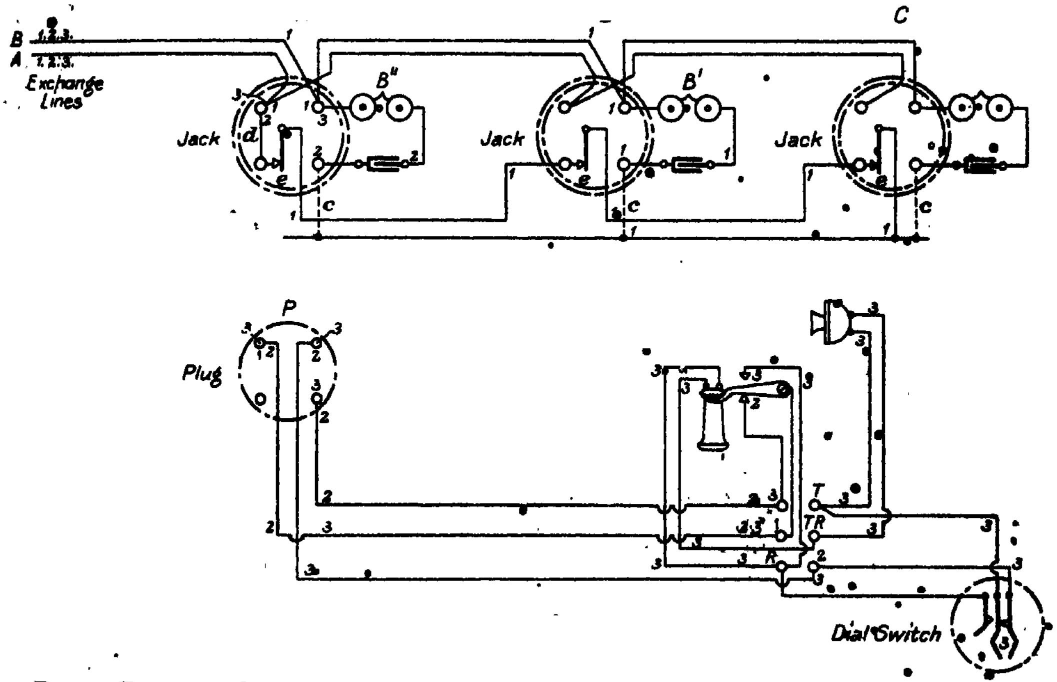

FIG 1.—EXTENSION LINES (A. T. M. CO.). TABLE TELEPHONE WITH WALL SOCKETS AND PLUG. PROVIDES FOR ONE BELL BEING IN CIRCUIT.

to all the bells. The socket next the exchange line has two terminals strapped together by a wire *d*, to complete the series circuit. If we assume that socket *b* only has the connection *e* made, then a call will be received from the exchange on bell B′ over circuit 1. If the plug P is inserted in the socket A, then a call will be received on bell B″, and the circuit will be opened to the other bell. Circuit 3 is the speaking circuit. A call may be made from any one of the sockets by the impulse-dial.

Fig. 2 shows a corresponding arrangement on the *Siemens System*. A bell-set, including an induction coil, is fitted at each socket. The point which is to receive calls when the plug is not inserted must have the strap connection, *c*, across. The bell circuits are again through series contacts *e*. The circuits are numbered as before, 3 being the microphone circuit and 4 the receiver circuit. At B is shown an explanatory circuit.

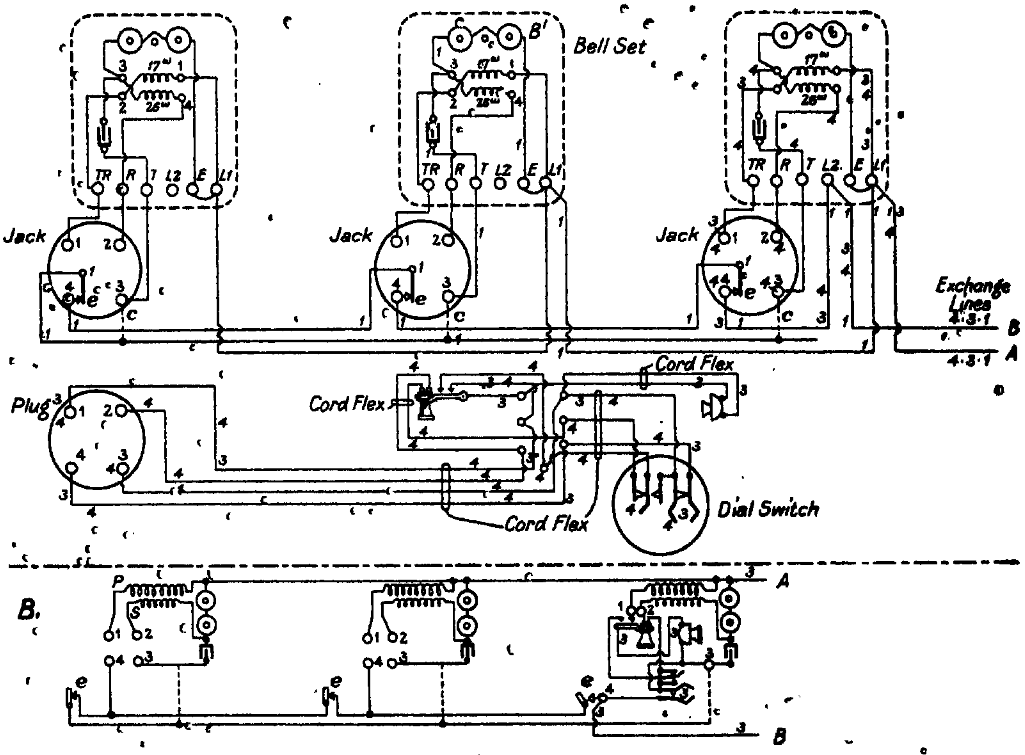

FIG. 2.—EXTENSION LINES (SIEMENS). TABLE TELEPHONES WITH WALL SOCKETS AND PLUG.

In the two systems mentioned two bells must not be in parallel on the line, and in the circuits shown the necessary precautions are taken to prevent this. This prevents the possibility of premature tripping of the exchange ringing when a subscriber is being called, or interference with the dialling impulses owing to condenser bridges on the line.

A corresponding arrangement for the W. E. Co.'s system is shown in Fig. 3. In this system the objection to bell and condenser bridges is not so great, and this simpler circuit is sufficient. A bell-set with condenser is fitted at the A socket and a bell only at the other two. The induction coil is common to all the sockets. In the plug a connection is made

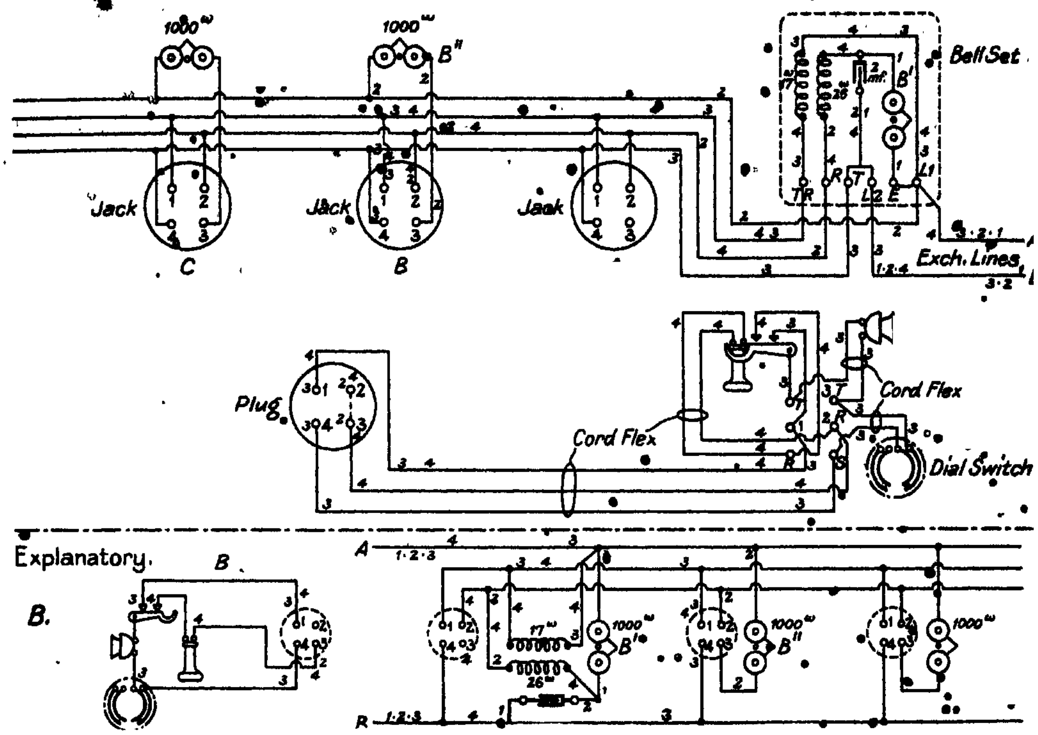

Fig. 3.—Extension Lines (W. E. Co.). Table Telephones with Wall Sockets and Plug.

between terminals 2 and 3. The diagram circuits are numbered, to agree with the previous diagrams, and the explanatory circuit at B will make the arrangement clear.

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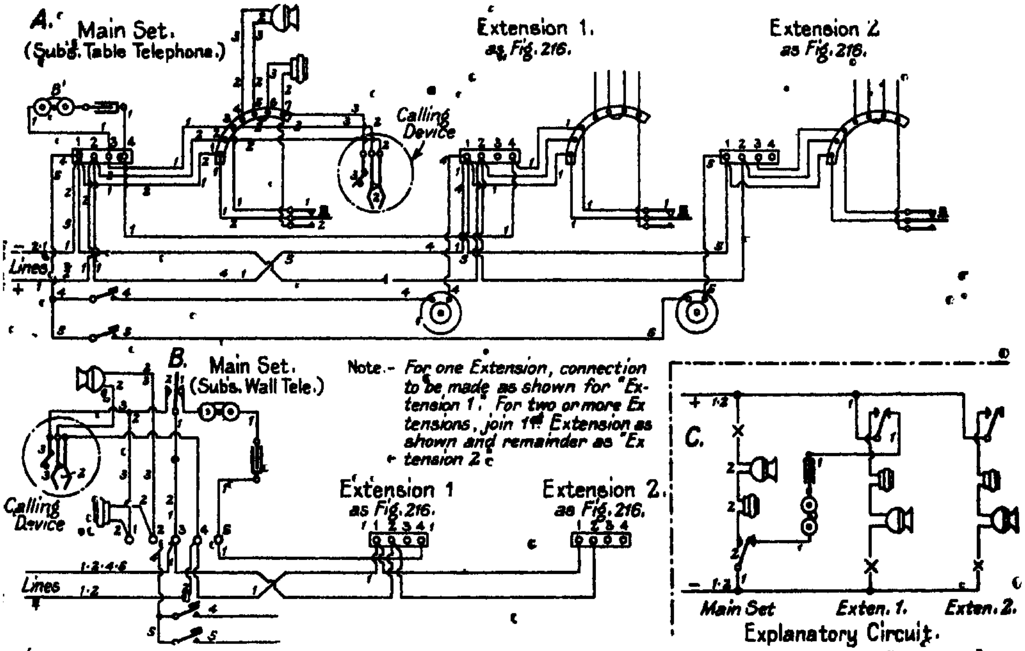
Section 2

EXCHANGE LINES WITH SIMPLE EXTENSIONS AT SUBSCRIBERS' OFFICES

Fig. 4 shows an A. T. M. Co. circuit for a plurality of instruments. A polarised bell is fitted at the *main* instrument only, so that all inward calls are received at this point. A dial is fitted at each instrument for originating outward calls. At A is shown a wiring diagram with a table instrument at the main office and table instruments at the extensions. At B a wall instrument is fitted at the main office. At C is an explanatory circuit. A push-button switch is fitted at the main office for each extension instrument, and a trembler bell is fitted at each extension, current for ringing these being drawn from the central battery over the exchange line. When a call is received for an extension office the switch is pressed, and when the extension receiver is lifted the instrument is connected in parallel across the exchange line. When the main or first extension telephone is in use the polarised bell is cut out of circuit, but when the second extension is in use, the bell and condenser are a shunt across the circuit. The extension instruments are wired according to diagram (Fig. 5).



Note.- For one Extension, connection to be made as shown for "Extension 1." For two or more Extensions, join 1st Extension as shown and remainder as "Extension 2."

FIG. 4.—EXTENSION LINES (A. T. M. CO.). SUBSCRIBER'S TABLE AND WALL SETS WITH SIMPLE EXTENSIONS.

The principle circuits of Fig. 4 are numbered as follows:—

1. Ringing circuit for inward calls.

2. Calling or microphone circuit of main station. Dialling from the main station opens circuit 2.

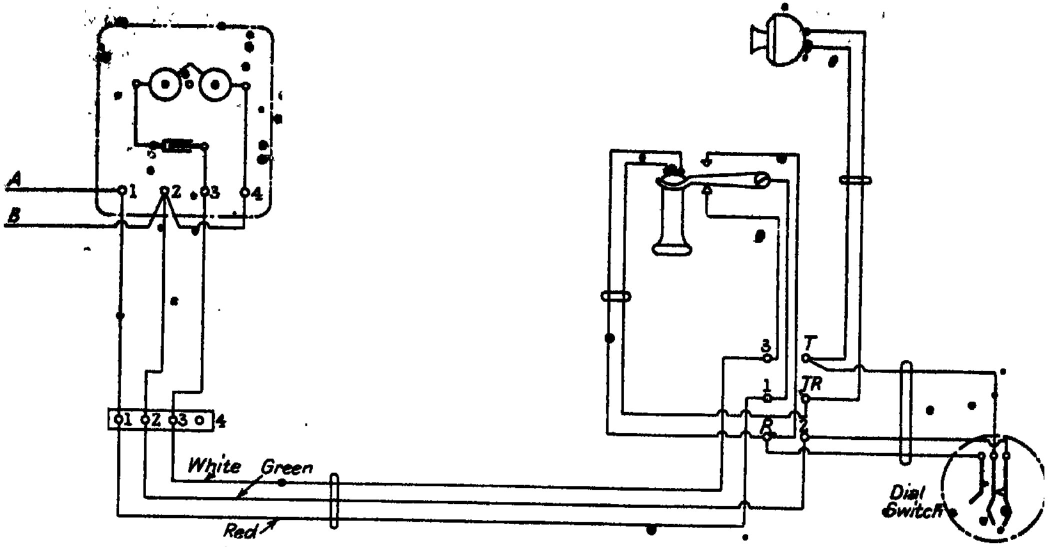


FIG. 5.—TABLE INSTRUMENT CIRCUIT (A. T. M. Co.).

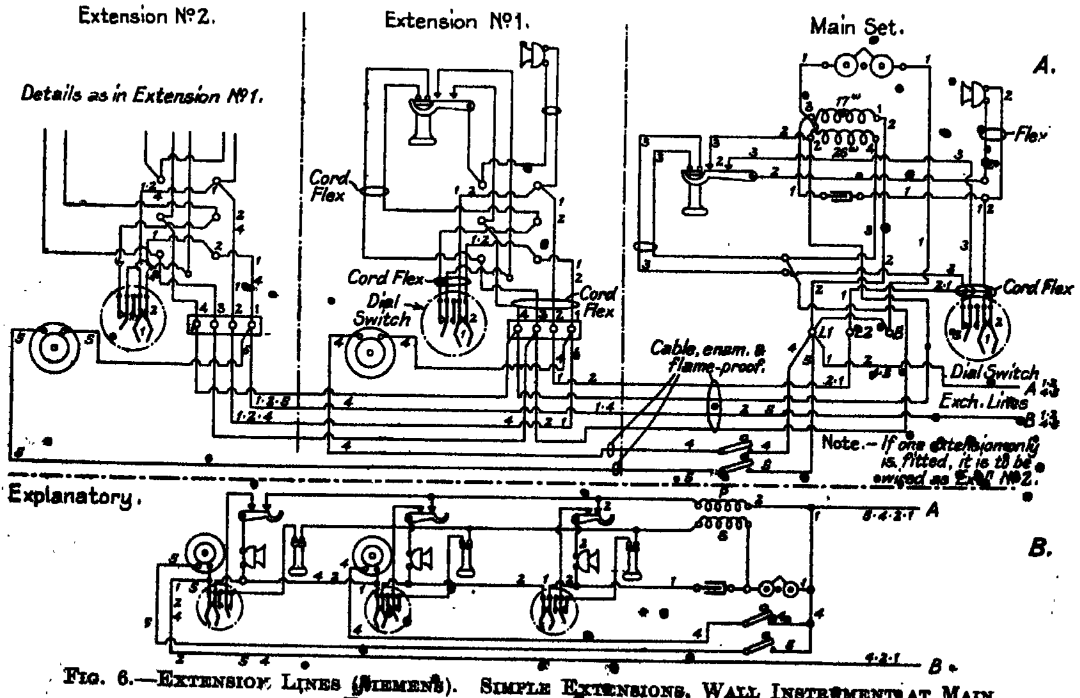


FIG. 6.—EXTENSION LINES (SIEMENS). SIMPLE EXTENSIONS, WALL INSTRUMENT AT MAIN, TABLE INSTRUMENTS AT EXTENSIONS.

3. Short-circuit about receiver and transmitter during impulsing.
4. Ringing circuit to call extension No. 1.
5. Ringing circuit to call extension No. 2.

Fig. 6 shows a Siemens circuit for a main instrument and two extensions. A polarised bell and an induction coil are at the main station only. A dial is fitted at each station so that outward calls can be originated from any point. Inward calls are received at the main station, and any extension can be called by pressing a switch, current then being drawn over the exchange line to ring a trembler bell. At A is shown a wiring diagram, and at B an explanatory one. The circuits are numbered in a manner corresponding to the previous diagram, but in the case of circuit 3 the receiver circuit is opened instead of being short-circuited.

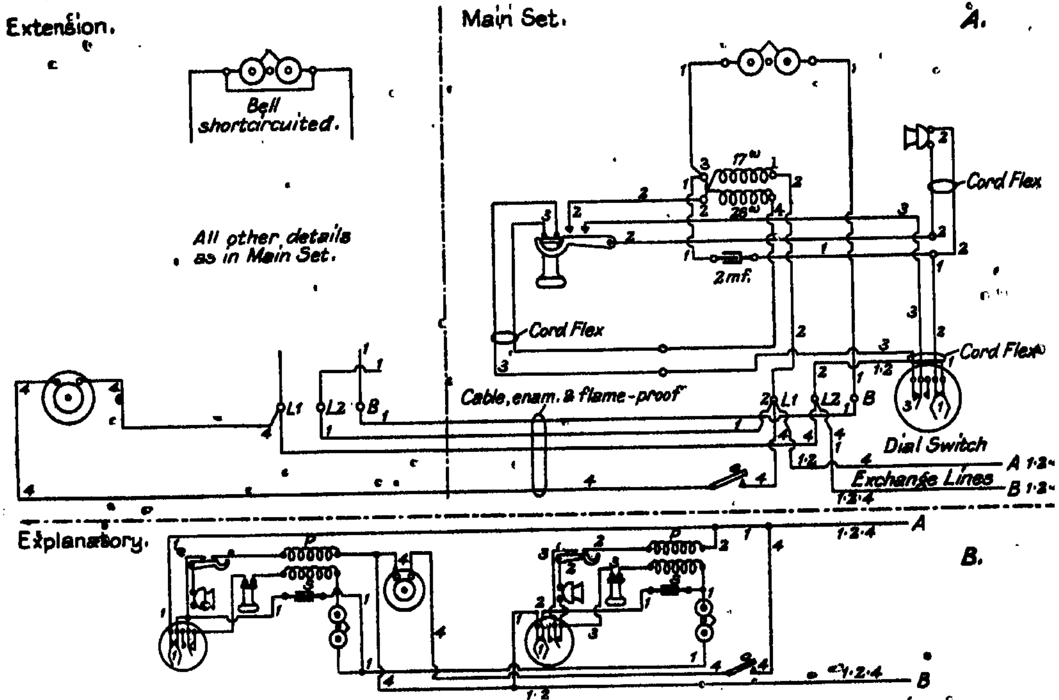


Fig. 7.—Extension Lines (Siemens). Simple Extensions (Wall Instrument).

In Fig. 7 is shown another simple circuit with a bell at the main station for inward calls, that at the extensions being short-circuited. Wall instruments are used throughout. There is an induction coil at each instrument. Again, there is a push-button switch at the main instrument for each extension and a trembler bell at each extension operated by current drawn over the exchange line. Outward calls can be originated from any instrument by the dial provided. The circuits are numbered as described for Fig. 4, the receiver circuit being opened whilst dialling.

In Fig. 8 is shown a similar circuit arranged for table instruments throughout, but resembling Fig. 7 in that there is a bell and induction coil at the main instrument only.

Fig. 9 shows still another Siemens circuit, but having a secrecy switch, so that when a call is received at the main instrument for the extension, the push switch is pressed to call the extension, and the secrecy switch operates when the extension can converse over the exchange circuit without being overheard at the main instrument. The switch should be fitted at the extension and be reset after conversation. It opens circuits 1 and 3. There is a bell (polarised) at the main instrument only, but an induction coil is fitted at each instrument.

Fig. 10 shows a W. E. Co. simple extension using table instrument only. A polarised

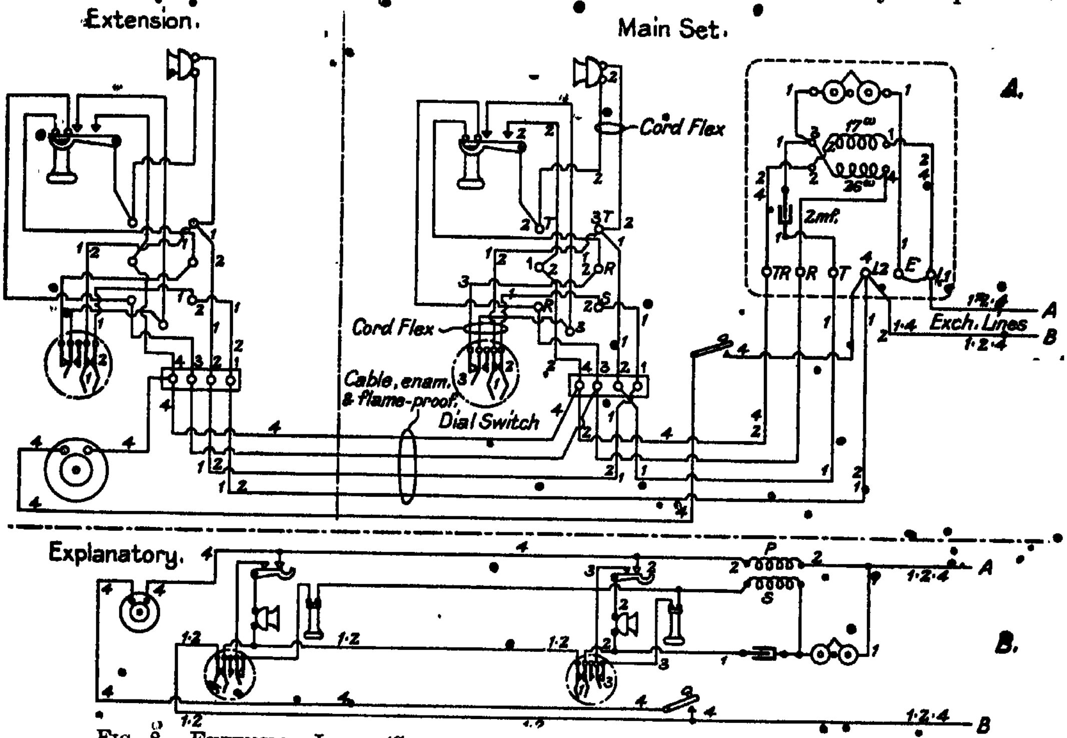


FIG. 8.—EXTENSION LINES (SIEMENS). SIMPLE EXTENSIONS (TABLE INSTRUMENTS).

bell is fitted at the main instrument only, for inward calls. A dial is at each instrument for originating outward calls. An induction coil at the main instrument is common to it and the extension. At the main instrument is fitted a push switch for calling the extension on a trembler bell, operated by current drawn over the exchange line. At A is shown the wiring diagram and at B an explanatory diagram.

The circuits are numbered similarly to the preceding simple extension circuits, and are as follows :—

1. Ringing circuits for inward calls.
2. Calling and microphone circuit of main station. Dialling from the main station opens circuit 2.
3. Short-circuit about receiver during impulsing.

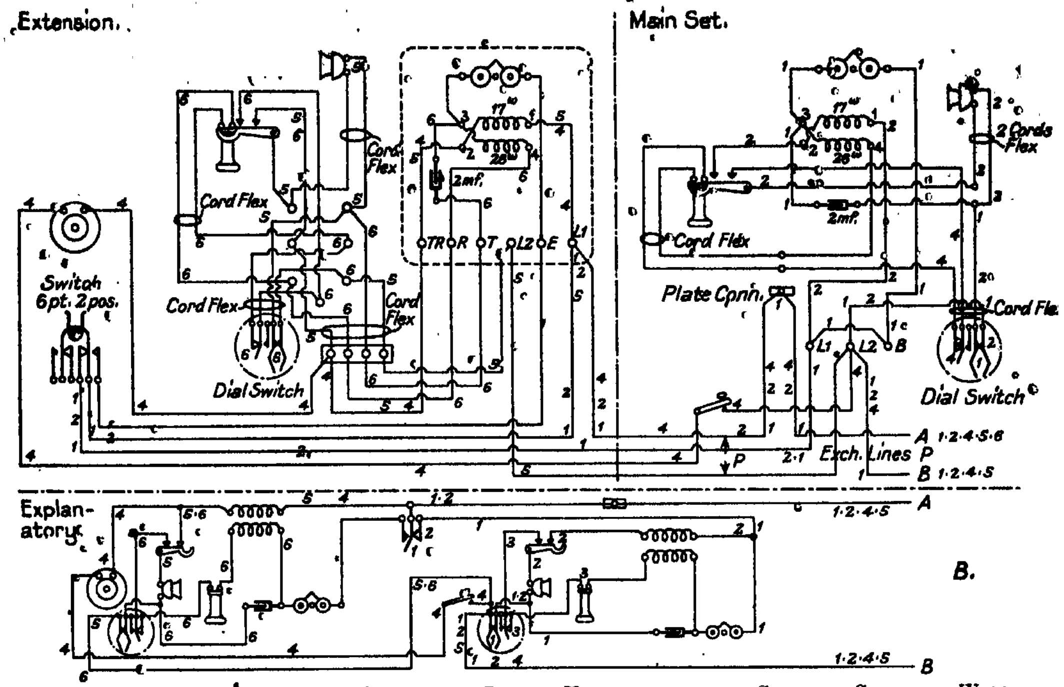


FIG. 9.—EXTENSION LINES (SIEMENS). SIMPLE EXTENSIONS WITH SECRECY SWITCH. WALL INSTRUMENT AT MAIN, TABLE AT EXTENSIONS.

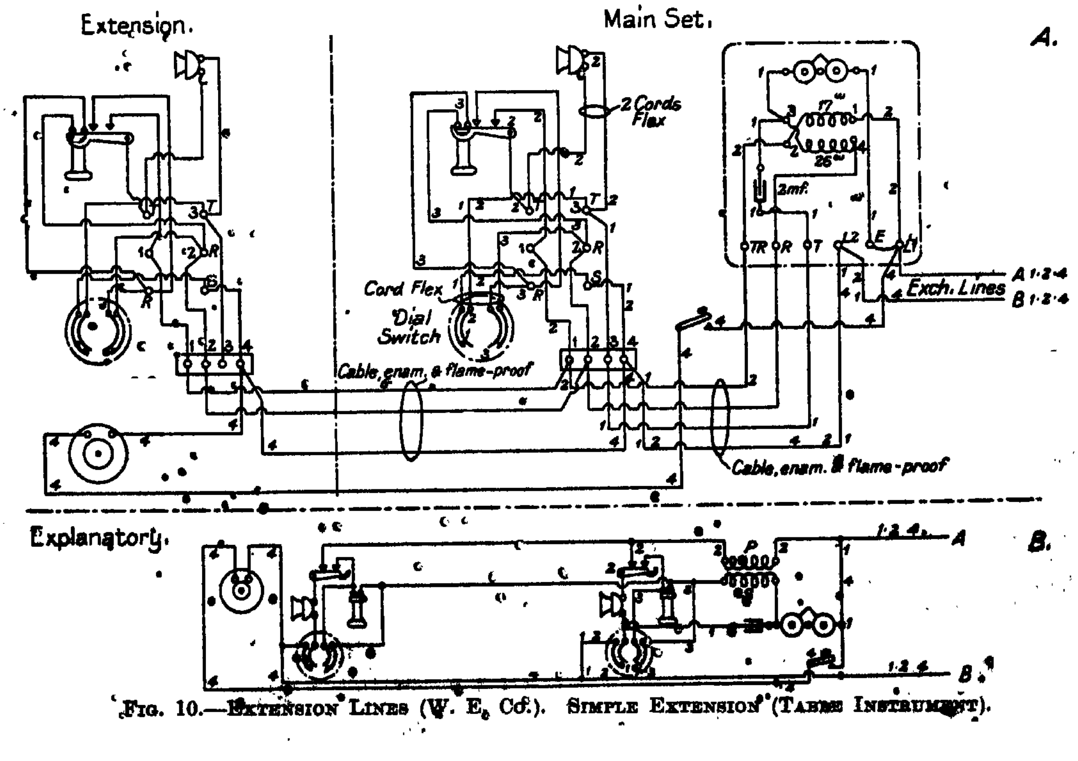


FIG. 10.—EXTENSION LINES (W. E. CO.). SIMPLE EXTENSION (TABLE INSTRUMENT).

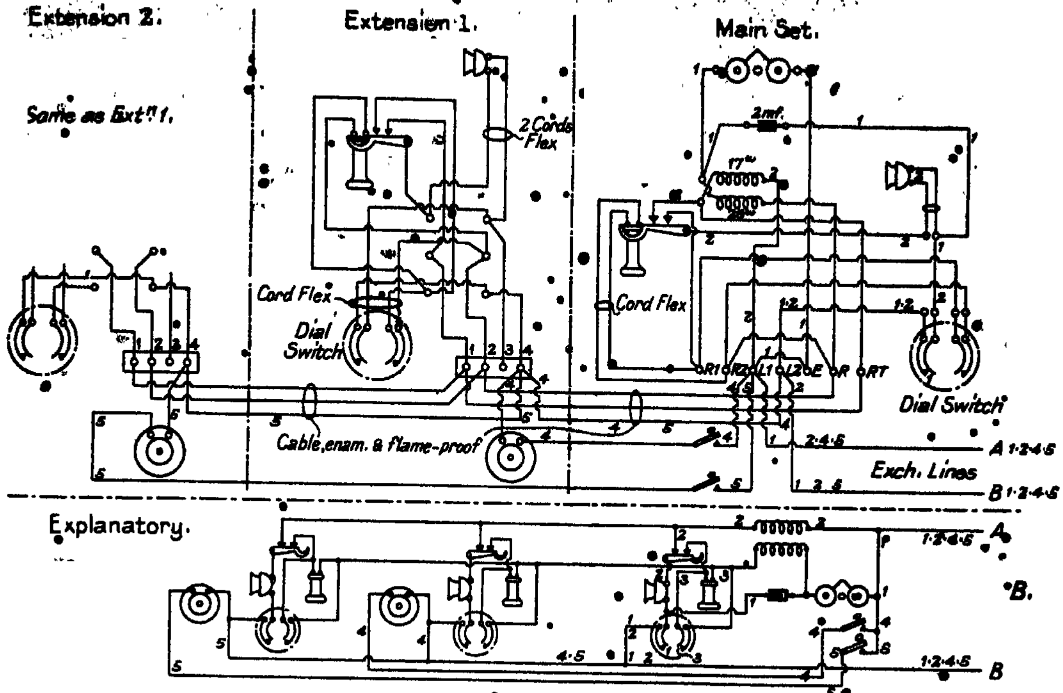


FIG. 11.—EXTENSION LINES (W. E. CO.). SIMPLE EXTENSIONS. WALL INSTRUMENT AT MAIN, TABLE AT EXTENSIONS.

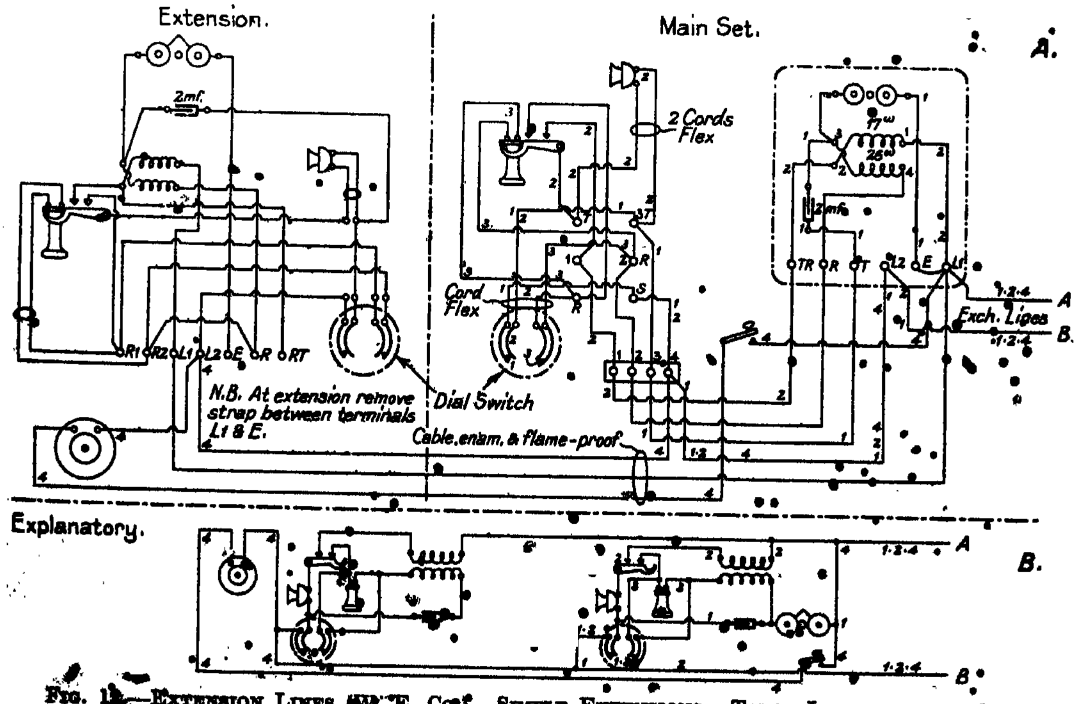


FIG. 12.—EXTENSION LINES (W. E. CO.). SIMPLE EXTENSIONS. TABLE INSTRUMENT AT MAIN, WALL INSTRUMENTS AT EXTENSIONS.

4. Ringing circuit to call extension 1.

Fig. 11 shows a similar circuit for two extension instruments, that at the main being a wall set and at each extension a table set.

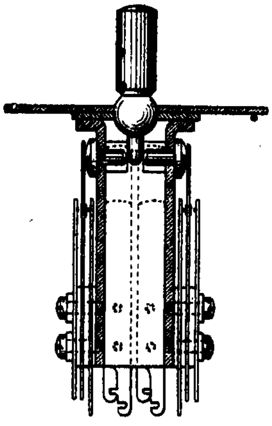
The circuits are numbered as in the previous diagram. Circuit 5 is that of the second extension bell.

Fig. 12 shows a W.E. Co. arrangement with a table set at the main office, and a wall set at the extension. The polarised bell at the extension is left disconnected. The extension is called by a trembler bell operated from the main office. There is an induction coil at each instrument. The principal circuits are numbered as for the previous diagrams.

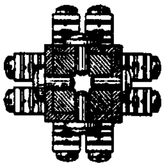
Section 3

EXTENSION LINE WORKING WITH INTERMEDIATE THROUGH SWITCH

Post Office Bell-Set, No. 4.—There is a main office and an extension on an exchange line. The main instrument is equipped with a dial so that outward calls may be originated. The switch is primarily designed to give secret service when the main or extension is talking to the exchange, but it can be adapted for non-secret working. This bell-set was originally designed by the author, the 4-way switch shown in Fig. 13 being used, and *drum* battery indicator (Fig. 14).



Vertical Section



Horizontal Section

FIG. 13.—FOUR-WAY KEY (A. T. M. Co.).

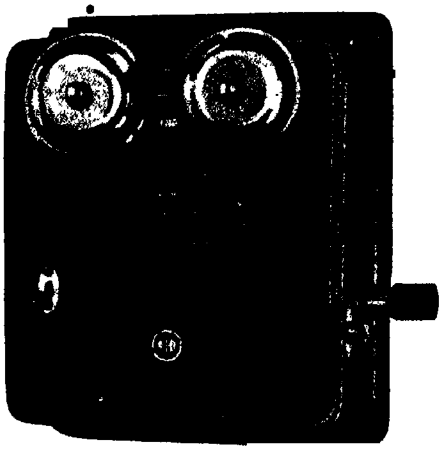
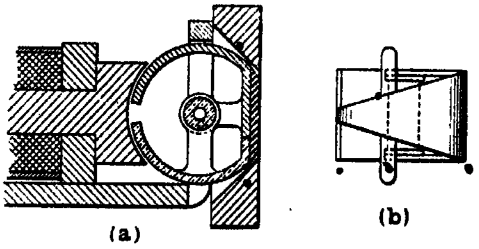


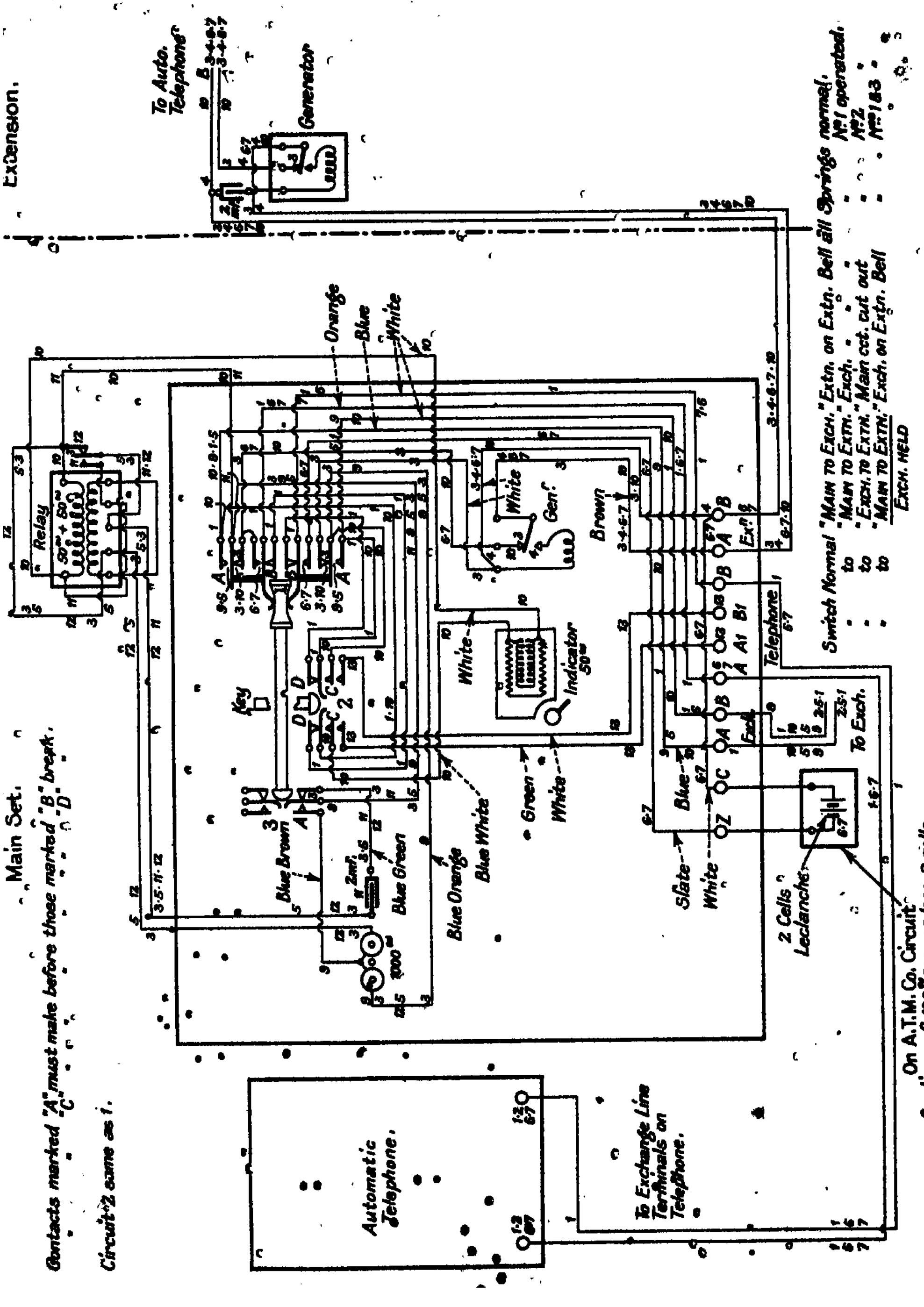
FIG. 13A.—INTERMEDIATE SWITCHING SET AS USED BY POST OFFICE (A. T. M. Co.).



(a) Normal Position (Section).

(b) Drum or Moving Part.

FIG. 14.—DRUM INDICATOR (A. T. M. Co.).



Switch Normal "Main to Exch." "Extn. on Extn. Bell all Springs normal.
" to "Main to Extn." " Exch. " " " No. 1 operated.
" to "Exch. to Extn." "Main cct. cut out " No. 2 "
" to "Main to Extn." "Exch. on Extn. Bell " Nos. 1 & 3 "
Exch. held

On A.T.M. Co. Circuit
for lines of 100ω res. or less 2 cells
" " " 100ω to 200ω res. 3 "
" " " 200ω to 350ω " 4 "
" " " over 350ω " 5 "

Contacts marked "A" must make before those marked "B" break.
" " "C" " " " " " "D" "

Circuit 2 same as 1.

FIG. 15.—POST OFFICE BELL-SET NO. 4A FOR AUTOMATIC WORKING. JOINED UP FOR SECRECY.

Fig. 15 shows a Post Office circuit using a 3-position key, and Fig. 16 shows a Post Office circuit using a 4-position switch. Fig. 17 is an explanatory circuit for both these diagrams, all three having the circuits similarly numbered.

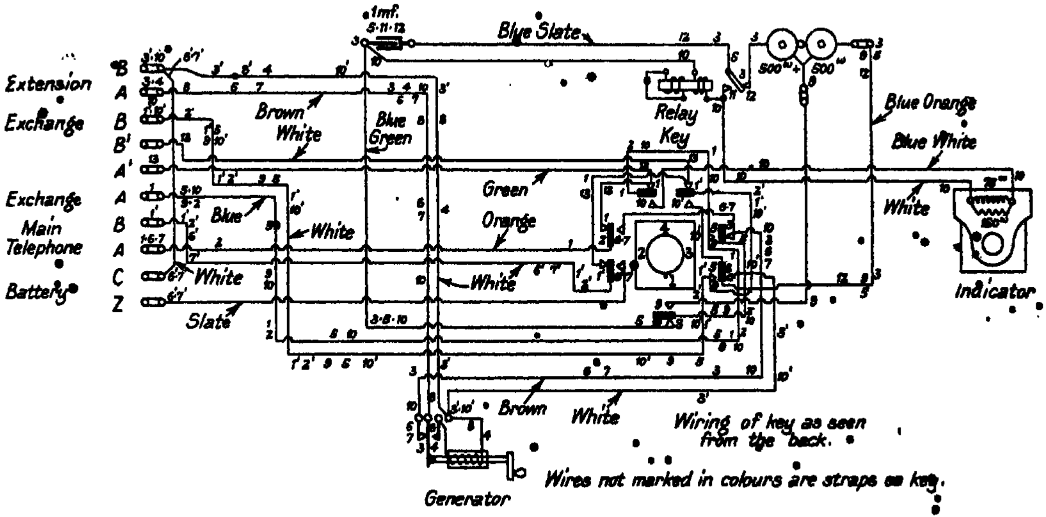
In Fig. 15 the circuits completed in the different positions of the switch are as follows :—

Normal.—Main connected to the exchange, extension line on bell.

Position 1.—Main connected to extension, exchange on bell.

Position 2.—Exchange to extension, circuit to main cut.

Position 3 (*springs* 1 *and* 3 *actuated*).—Main to extension, exchange on extension bell. Exchange held.



Wiring of key as seen from the back.

Wires not marked in colours are straps as key.

In normal position central springs are in contact with outers, when actuated they are in contact with inners.

Pointer to position 1 all springs normal Main to Exchange, Extension on Extension Bell.
" " " 2 springs 2 and 3 actuated Main to Extension, Exchange on Extension Bell.
" " " 3 " 1, 2 & 3 " " " " " held.
" " " 4 " 4 " Exchange to Extension.

FIG. 16.—POST OFFICE BELL-SET NO. 4. JOINED UP FOR SECRECY.

In Fig. 16 these are as follows :—

Normal.—Main to exchange, extension on extension bell.

Position 2 (*spring sets* 2 *and* 3 *actuated*).—Main to extension, exchange on bell.

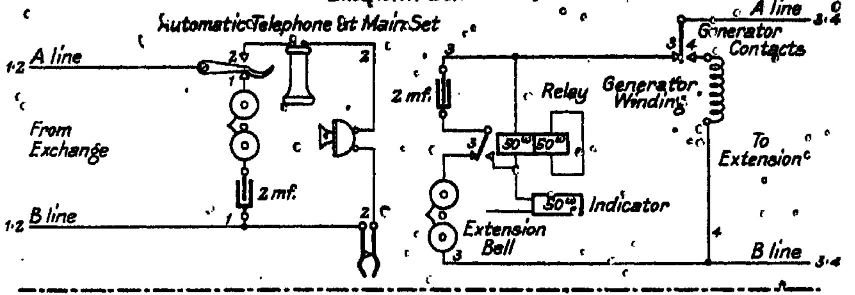
Position 3 (*spring sets* 1, 2, *and* 3 *actuated*).—Exchange to extension, exchange held.

Position 4 (*spring set* 4 *actuated*).—Exchange to extension.

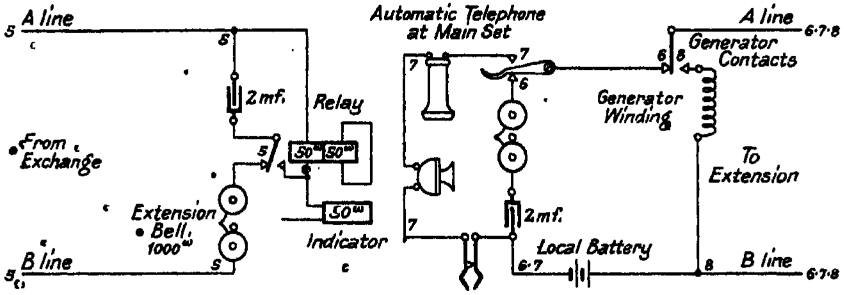
The circuits are numbered as follows :—

1. Ringing circuit of exchange line on bell at main.
2 (over 1). Talking circuit to main.
3. Extension line on extension bell.
4. Generator circuit for calling extension.
5. Exchange on extension bell.
6. Extension on main bell.

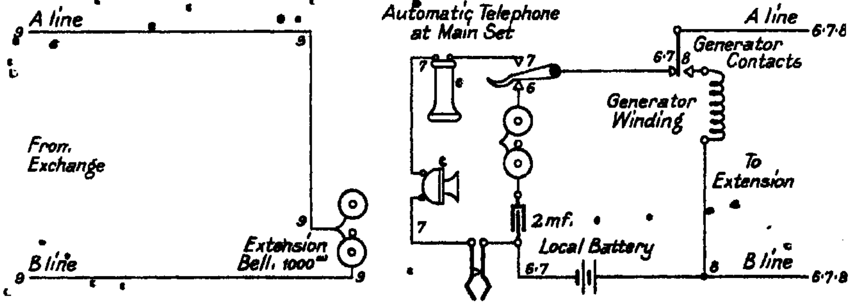
A.—Switch Lever Normal.—*Main Telephone on Exchange, Extension on Extension Bell.*



B.—Switch Lever in "Extension" Position.—*Main on Extension, Exchange on Extension Bell.*



C.—Switch Lever in "Main Set to Extension, Exchange Held" Position.



D.—Switch Lever in "Extension to Exchange" Position. *Note:—Relay is made slow-acting by shortcircuiting one winding. This prevents the signalling impulses actuating the Extension Bell.*

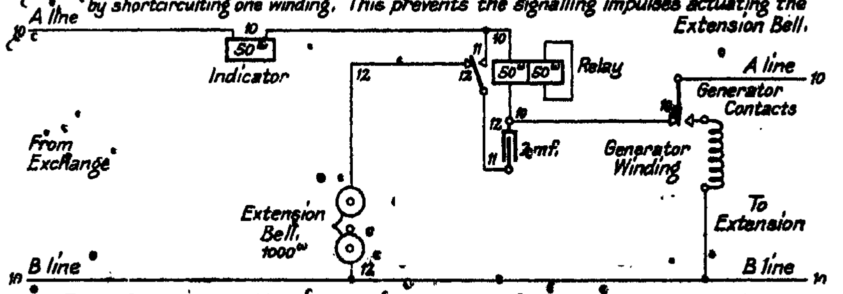


FIG. 17.—POST OFFICE BELL-SET NO. 4, USED FOR AUTOMATIC WORKING. EXPLANATORY CIRCUITS.

7. Extension talking to main.
8. Generator circuit to call extension (same as 4).
9. Exchange line holding circuit.
10. Exchange to extension line, talking circuit.
11. Condenser shunt across 50-ohm coil of relay.
12. Bell bridged across loop (*i.e.* across circuit 10, by release of relay when the extension receiver is replaced).

The voltage of the battery for talking between the main and the extension should be varied according to the resistance of the line. For particulars see the figures on the diagram.

When the switch is to be used for non-secret working, a strap is connected between the terminals A and A′ and between B and B′. Circuit 13 then connects the main instrument in parallel with the exchange-extension circuit.

Section 4

DIRECT AND PARTY LINES FITTED WITH COIN BOXES

For call offices, hotels, and other public places, where the user must pay for each conversation, such coin boxes are very desirable. Party-line working is also a very suitable field for them, because a meter at the central office could not readily be made to differentiate between two offices which might be rented by two parties having no relationship one to the other.

In such equipments it is essential that a client be able to call the exchange without fee, and also be able to call the party wanted, and, if the line is engaged, pay no fee; but if the party replies a fee must then be paid. The party called must be able to indicate his attendance at the telephone, but it must be impossible to carry on a conversation until the fee is paid. A system designed by the Automatic Electric Company, Chicago, is the only one in general use.

Fig. 18, showing a circuit of an arrangement based on the above system, by the A. T. M. Co., is used as an explanatory diagram. The essential apparatus, in addition to the telephone instrument and coin box having a chute, is a polarised relay. This resembles the polarised bell movement of a telephone instrument, and acts as a 2-way electro-mechanical switch. When a call is made and the battery on the line reversed by the lifting of the called receiver, the microphone is short-circuited and the receiver is shunted by a 30-ohm coil. The caller cannot, therefore, communicate with the called party, but the response of the called party can be heard. The receiver is rendered inefficient so that it cannot be used as a transmitter. When a coin is inserted in the chute, or a coin inserted and a lever turned, the short-circuit and shunt are removed, so that conversation can take place.

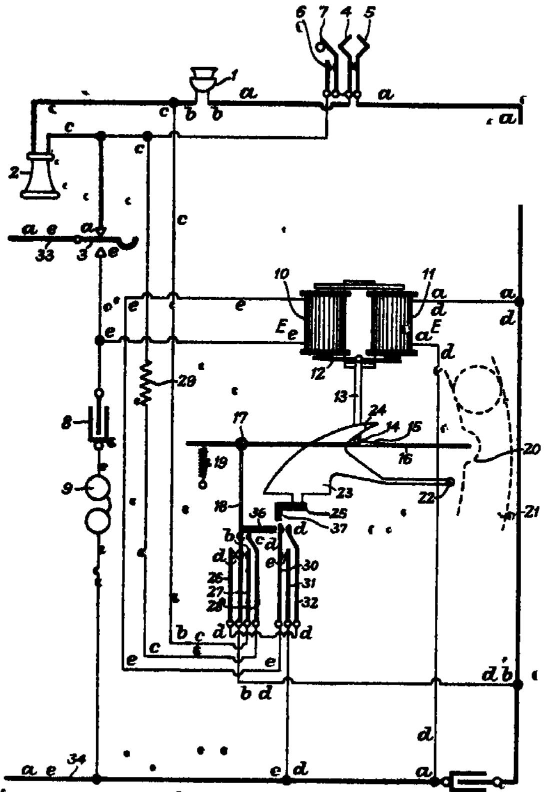


FIG. 18.—PAY STATIONS, EXPLANATORY CIRCUIT OF COIN BOX (A. T. M. Co.).

The battery on the line is not reversed when the call is to an "information" operator, or when handing in a trunk call, or the like, and no fee is payable. A buzzer in such cases indicates to the operator that the call is from such a pay-station.

The circuits of the explanatory diagram are as follows:—

a. When the receiver is lifted to call the magnet *a*E is energised and the armature is repelled. The extension 14 is moved over the lug 15 to the position shown in the diagram. The number wanted is then dialled. When the called party answers the current in circuit *a* is reversed, and the armature 12 is attracted to the coil *a*E. The extension 14 on arm 13 now engages with the lug 15 and moves the floating arm 16 to the right. The moving spring 18, on which the arm 16 is pivoted, closes a set of contacts.

b. Short-circuit about the microphone.

c. Shunt about the receiver. The calling subscriber can hear, but cannot speak.

As the extension 14 moves to the right the lever 23 falls, and, as the spring 30 has been carried to the right by the insulated pencil 36, the insulated part 37 falls behind spring 30 and locks it in this operated position until the receiver is replaced. This lever is not shown in the following Post Office circuits, but is provided, in this case, to meet trouble that sometimes happens, due to the receiver being replaced when the party first answering has to bring another party to the telephone, and the like, when the current in the line is restored to its normal condition. A second reversal then takes place, and as the switch has meantime gone back to normal and again energised, a second coin has to be inserted.

When the called party is heard on the line, a coin is immediately inserted in the chute 21, when the end of the arm 16, shown projecting into the chute, is depressed against the action of spring 19, until the extension 14 is free to pass over the lug 15. The arm 16 then passes to the left by the tension of spring 18, when the circuits *b* and *c* are opened.

d. Short-circuit about coil *a*E. Should the called receiver be wrongfully replaced and again removed, the battery reversals will not affect the calling apparatus.

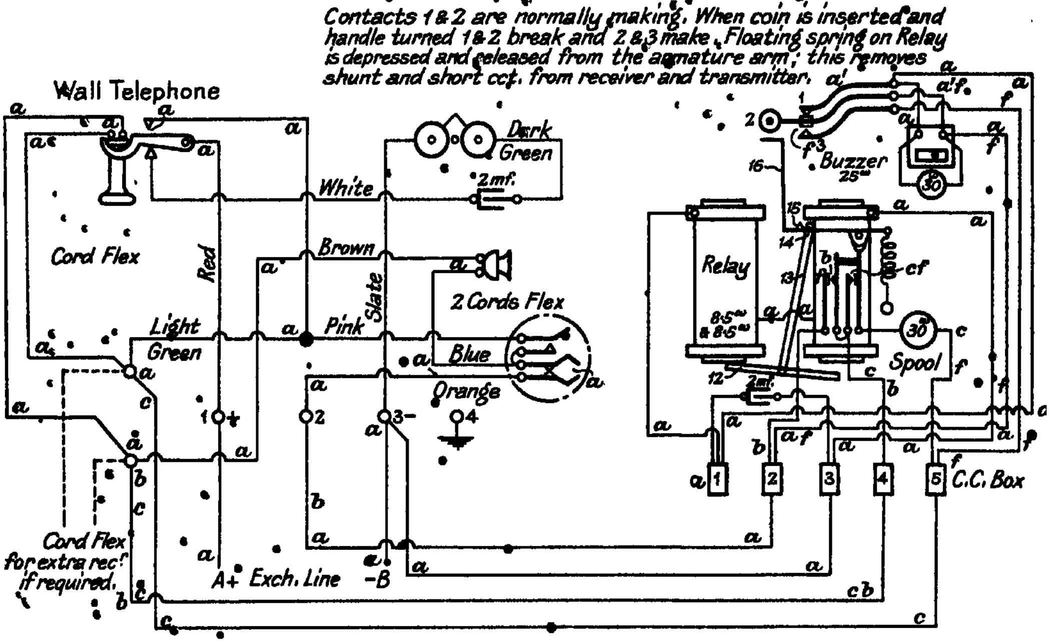
e. High resistance winding *e*E energises and returns armature 12 to normal. The extension 14 lifts the lever 23 and circuits *e* and *d* are opened.

When the calling receiver is replaced, the apparatus is restored to normal, and the exchange apparatus released.

Section 5

POST OFFICE CIRCUITS FOR COIN-BOX LINES

These differ somewhat from the theoretical circuit before described. The lever 23 is not used and the polarised relay has its two coils connected in series, the resistance of each being 8·5 ohms. In addition to a coin being inserted in the chute, a handle or lever is turned so that the weight of the coin does not control the movement. When connection is made to an information operator, a trunk record operator, and the like, such services requiring no fee to be paid, the line battery is not reversed. A buzzer is included, so that these may be used on manual systems when the operator will hear the buzz on the line and be able to check the number of coins inserted, in a known manner.



Contacts 1 & 2 are normally making. When coin is inserted and handle turned 1 & 2 break and 2 & 3 make. Floating spring on Relay is depressed and released from the armature arm; this removes shunt and short cct. from receiver and transmitter.

Modification for Party Line working.

For "X" Party. *Fit an additional terminal. (4), as shown in the explanatory sketch on Fig. 20 in dotted lines, and connect to earth. Transfer the wire from the back contact of the switch arm to terminal 4.*

For "Y" Party. *Fit additional earth terminal (4) as above. Disconnect at terminal 3 the wire from th wire from the bell coil and connect it to Terminal 4 and strap the switch arm to bac contact.*

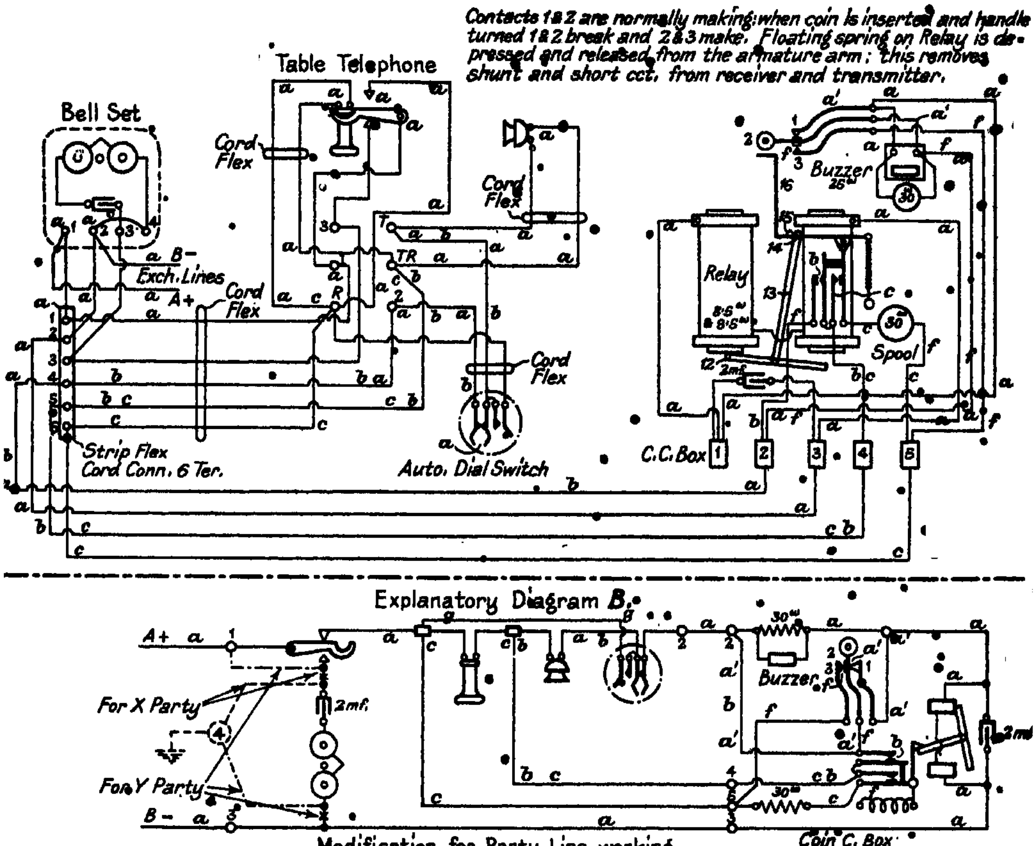
Note.-For Table Set see Fig. 20.

Fig. 19.—Pay Station. Wall Instrument Circuit (A. T. M. Co.). As used by British Post Office.

Fig. 19 shows the combination of a wall instrument with such a coin box, and Fig. 20 a table telephone. The explanatory diagram B applies to both wiring diagrams.

The circuits are numbered and are as follows:—

a. When the receiver is lifted to make a call, a circuit is completed through the polarised relay switch (which is shunted by a condenser). The relay is set in the position shown in the diagram, as described for Fig. 18.



Contacts 1 & 2 are normally making: when coin is inserted and handle turned 1 & 2 break and 2 & 3 make. Floating spring on Relay is depressed and released from the armature arm; this removes shunt and short cct. from receiver and transmitter.

Modification for Party Line working.

For "X" Party. Connect terminal 3 of Bell Set to earth instead of to Strip Flex Cord connection B terminal.
For "Y" Party. Remove strap between terminals 3 & 4 on Bell Set and connect terminal 4 to earth. Strap terminals 1 & 3 on Bell Set.
Note.—For Wall Set see Fig. 19.

FIG. 20.—PAY STATION. TABLE INSTRUMENT AND EXPLANATORY CIRCUITS (A. T. M. CO.). AS USED BY BRITISH POST OFFICE.

a′. The short-circuit about the buzzer.

The caller dials the number wanted. The coin should be in the entrance of the chute, so that immediately a response is heard it is released and the lever turned.

When the called party lifts the receiver to answer the call, the line battery is reversed. The polarised relay is energised in the reverse direction, and two contacts closed.

b. The short-circuit about the microphone.

c. The 30-ohm shunt about the receiver. The caller can, therefore, hear, but cannot speak.

When the lever is turned, circuit *a′* is opened and the buzzer tone is given to an operator, if the call is on a manual system.

f. The receiver is now totally short-circuited, so that the caller does not hear the buzz. The floating arm 16 is depressed so that the extension 14 of arm 13 passes over the catch 15 to return the relay to normal. The talking circuit is now complete with the receiver and microphone in series, through circuit *a* and *a′*. The received currents are through the condenser which shunts the polarised relay.

Such a device is very suitable for party-line working. For a direct line the bell and condenser are connected between the under contact of the switchhook and the B line. For party-line working the X subscriber's bell and condenser is tapped off the B wire and connected to earth. The Y subscriber's bell is tapped off the A wire.

Section 6

A. T. M. CO.'S COIN-BOX CIRCUIT WITH TONE SIGNAL

In the circuits previously described, the coin has to be dropped into the chute when the called party's voice is heard on the line. If there is any delay due to the caller not realising that the called party has answered, the latter may fancy it a wrong call and replace the receiver. In this alternative circuit (Fig. 21) a special tone signal is given to the caller when the called receiver is lifted to reply. A set of relays is associated with a trunk line to which a plurality of subscribers' lines has access. The circuits are numbered as follows :—

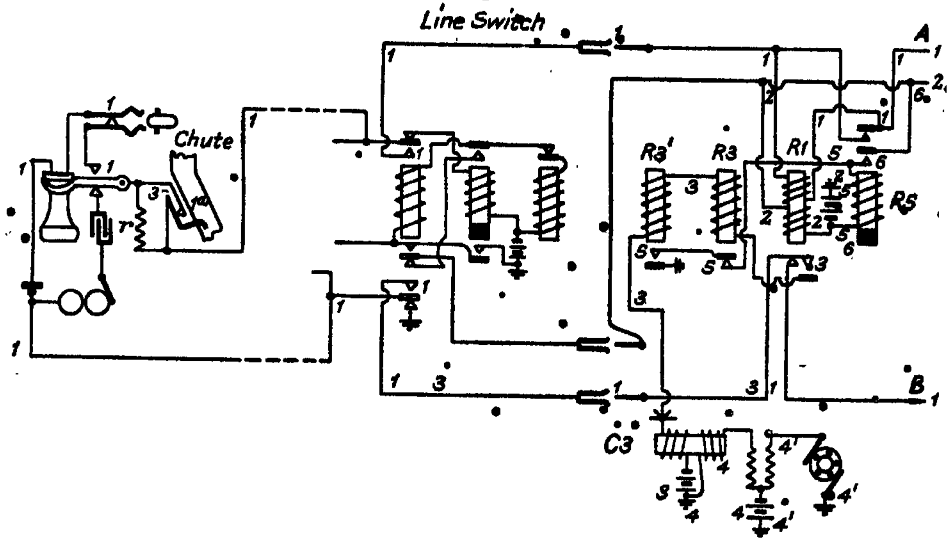


FIG. 21.—COIN-BOX CIRCUIT WITH TONE SIGNAL (A. T. M. Co.).

1. A calling line, by a line switch, extends a trunk line to a connector, in known manner, one winding of R′ being in circuit.

2. The other winding of R′ is in the third conductor circuit in which current is in the opposite direction, so that R′ does not energise.

3. When the called party answers, the current in the loop is reversed as elsewhere described, and, the currents in the two windings now assisting each other, R′ energises and opens the B wire towards the connector, and connects the calling side through relays R3 and R3′ (which energise) to coil C3, and to battery.

4. A tone signal is induced in circuit 3, which when heard in the receiver is a signal to insert a coin.

As the coin falls through the chute, contact 1*a* is opened, and resistance *r* inserted in the circuit. R3 de-energises, but not R3′.

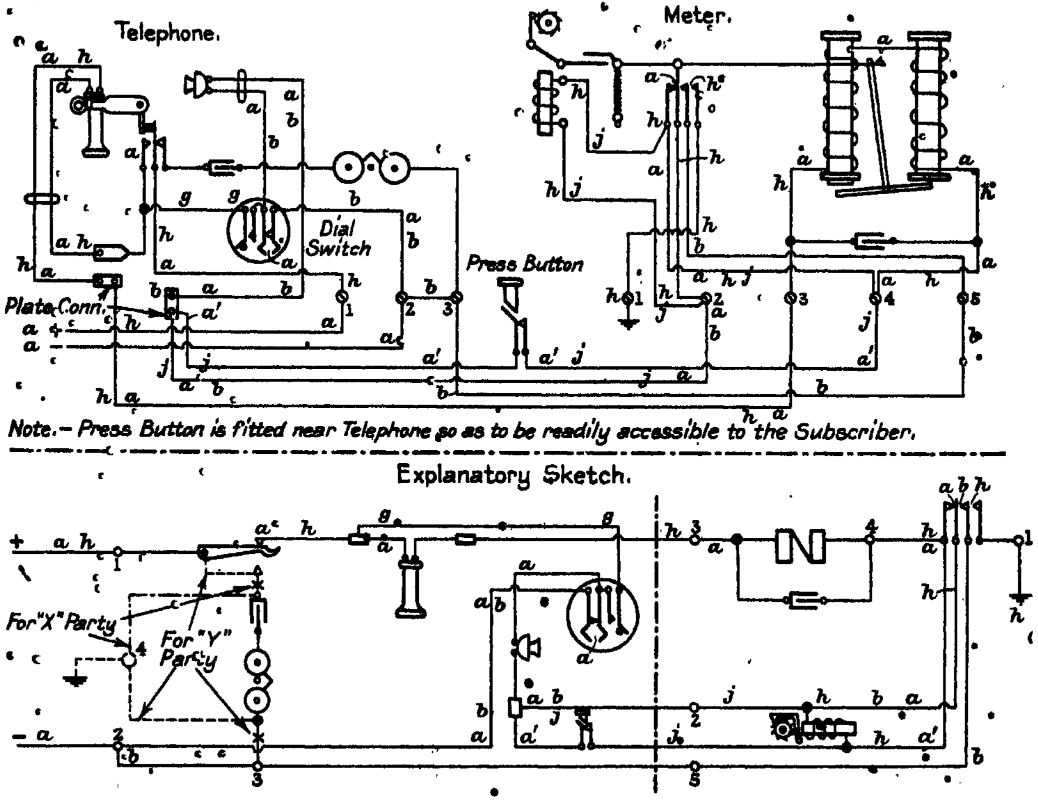
5. R5 energises.

6. R5 locking circuit. Winding 2 of R′ is short-circuited. R′ de-energises and completes the talking circuit.

Section 7

SUB-STATION CALL METER

Instead of the coin-box device previously described, it is sometimes preferred to use a meter to register the number of calls. The principal feature of such an installation is the polarised relay, of the type used in Fig. 18, which functions in a manner similar to that in the coin box. The relay is set when the receiver is lifted to make a call, is energised in the opposite direction when the line battery is reversed, and is restored to normal when the meter operates to register a call. The meter is normally short-circuited and is energised



Note.—Press Button is fitted near Telephone so as to be readily accessible to the Subscriber.

Explanatory Sketch.

Modification necessary for Party Line Working.

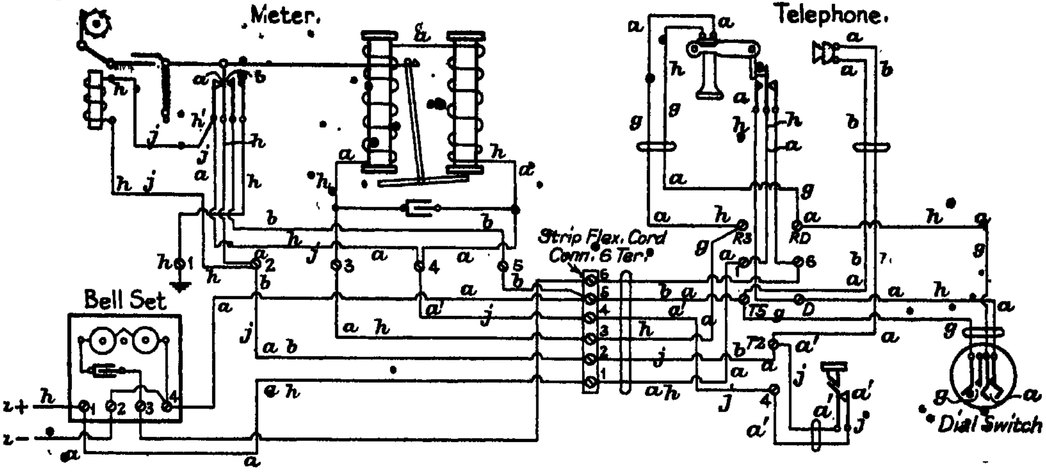
For "X" Party. *Fit an additional terminal (4) as shown in the explanatory sketch in dotted lines and connect to earth. Transfer the wire from the back contact of the switch arm to terminal 4.*

For "Y" Party. *Fit an additional terminal (4) as above. Transfer wire to the bell coil from terminal 3 to terminal 4, and strap the switch arm to bank contact.*

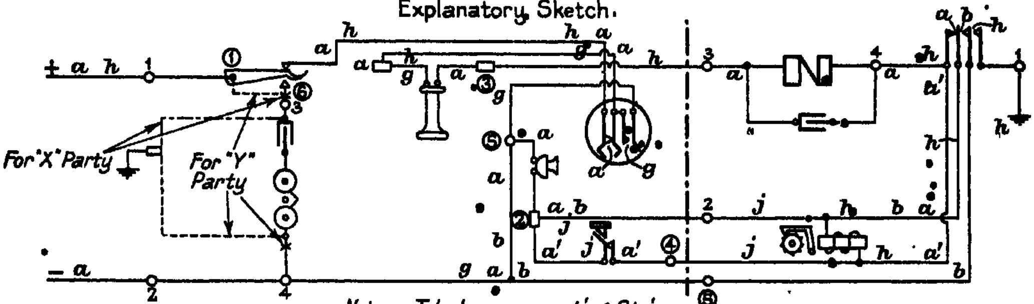
Note.—For wiring of Table Set see Fig. 23.

FIG. 22.—SUB-STATION CALL METER (A. T. M. CO.). WALL INSTRUMENT.

when a key is pressed to open the short-circuit, when current over the exchange line causes it to record. These may be fitted on direct lines, or on each of two stations on a 2-party circuit.



Explanatory Sketch.



Note.– Telephone connecting Strip Terminals marked ②

Modifications for Party Line Working.

For "X" Party. Connect terminal 3 on Bell Set to earth, instead of to terminal 6 on Strip Flex Cord connection.

For "Y" Party. Fit an additional terminal (5) on Bell Set and connect to earth. Transfer wire from bell coil from terminal 4 to terminal (5). Strap terminals 1 and 3 on Bell Set.

Note.– For wiring of Wall Set see Fig. 22.

FIG. 23.—SUB-STATION METER (A. T. M. CO.). TABLE INSTRUMENT.

The circuit, when used with a wall instrument, is shown in Fig. 22, and with a table set in Fig. 23. An explanatory diagram is shown at B in each case.

The circuits are numbered similarly in each case and are as follows :—

a. When the receiver is lifted to call, current is through the receiver, microphone, and polarised relay.

a′. Short-circuit about the meter.

The number required is dialled. When the called party answers, the relay is operated in the reverse direction, when one contact is opened and two closed.

b. Short-circuit about the microphone.

g. Short-circuit about the receiver when dialling.

j. When the key is pressed the short-circuit across the meter is opened.

h. Current is drawn over the positive wire (which has become negative) of the exchange line to earth at the relay springs. As the meter registers, it deflects the floating arm to permit the armature extension to ride over the catch to restore the circuit to the talking condition.

PARTY-LINE WORKING

FREQUENCY SELECTING CONNECTOR
FREQUENCY SELECTOR
REVERTING CALLS
TWO-PARTY CIRCUIT
LOCK-OUT AND RE-RINGING
HARMONIC RINGING

Section 8

PARTY LINES

This name is given to a metallic circuit on which there are a plurality of sub-stations. In this country only two stations on a circuit have been used on automatic systems. In the United States four are common and eight and ten used to a considerable extent.

The method of calling most generally used is the *harmonic-frequency* system, the different bells on the circuit being adjusted and biassed to respond to a different frequency (see Section 16).

Code ringing is used to some extent, at times in addition to the frequency method, in order to obtain selection of a greater number of stations.

Polarised bells, adapted to respond to positive and negative currents, are also used for four stations, one of each kind being tapped off the A wire and one of each kind off the B wire.

Lock-out devices, to prevent interference by stations other than the talking one, have been designed, but have not met with much favour, probably because of the additional complications on the circuit.

A few of the systems that have been used to a considerable extent are described.

Calling by Extra Digit.—Each connector has an auxiliary switching device, called a *frequency selector,* which is operated in response to impulses received from the caller, to select the particular ringing frequency for signalling the desired station.

Multipling the Party-lines over a Plurality of Connectors.—Each party-line is made accessible through as many groups of connectors as there are sub-stations on the called line; each group of connectors being accessible through a different level of the selectors. Each group of connectors is supplied with ringing current of a different character. In such a system the connecting efficiency of the connector is very low, as it will put through, on an average, only one-fourth of the calls to each line on its bank terminals (on a four-party line).

Discriminating by the Selector.—Each party line is accessible only through one group of connectors. This group, however, is accessible through as many different levels of the selectors as there are sub-stations on a line. Each connector is provided with means for connecting ringing current of different character to the called line, the particular ringing current which is connected to the line being dependent on the level to which the selector wipers have been raised.

Reverting Calls.—Usually special means are provided to enable one party to call another on the same circuit.

Section 9

PARTY-LINE FREQUENCY SELECTING CONNECTOR

This has a frequency-selecting switch combined with the usual connector. The special feature of this A. T. M. Co. switch is that the frequency is selected before the connection is made with the called line. The third-last digit, therefore, determines the frequency to be applied to the line.

The circuits of Fig. 24 are numbered as follows :—

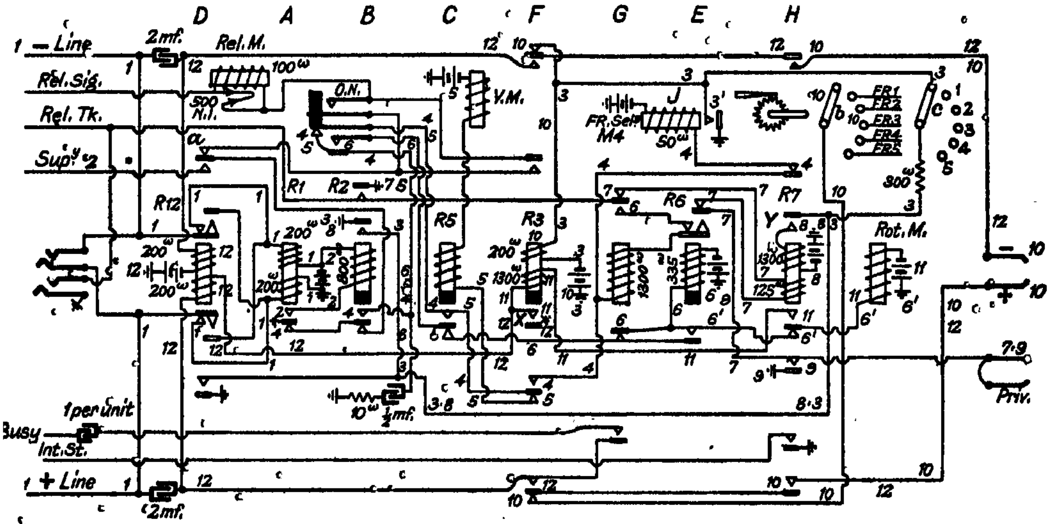
1. When the calling line is extended to the connector, R′ energises.

2. R2 (slow) energises.

3. R3 energises.

Frequency digit called. R′ de-energises intermittently.

4. Frequency-switch magnet M4 responds and steps the wipers *b* and *c* a distance corresponding to the digit. R3 is held over 3′ during the period of impulsing. Circuit 3 is now opened at wiper *c*, and R3 de-energises when M4 de-energises after the impulses.



Note :- *When this switch is used in a sub-office without selectors, short-circuit a, Relay D, so that release is controlled by the caller. Adjust armature spring X on Relay F so that it will just pull over against its make contact with 48 V. battery through 1950ω in series with the 200ω winding, but not through 2050ω res. Adjust contact Y on Relay H to make first.*

FIG. 24.—TWO-WIRE FREQUENCY SELECTING CONNECTOR (SIDE SWITCHLESS). SELECTS THE FREQUENCY BEFORE THE LINE. RELEASE WHEN LAST PARTY REPLACES RECEIVER.

The *tens digit* is now called, and R′ again de-energises.

5. R5 energises for the duration of the impulses, and the vertical magnet VM steps the shaft to the correct level. After the impulses R5 de-energises.

6. *Units digit now called.* R6 energises for the duration of the impulses.

6′. Rotary magnet RM steps the wipers round to the desired terminals.

7. *If the called line is idle.* When R6 de-energises after the impulses R7 energises.

8. R7 holding circuit.

9. Called line made busy.

10. Correct frequency applied to the called station. R3 does not energise. When the subscriber answers, R3 energises.

11. R3 holding circuit (RM does not energise).

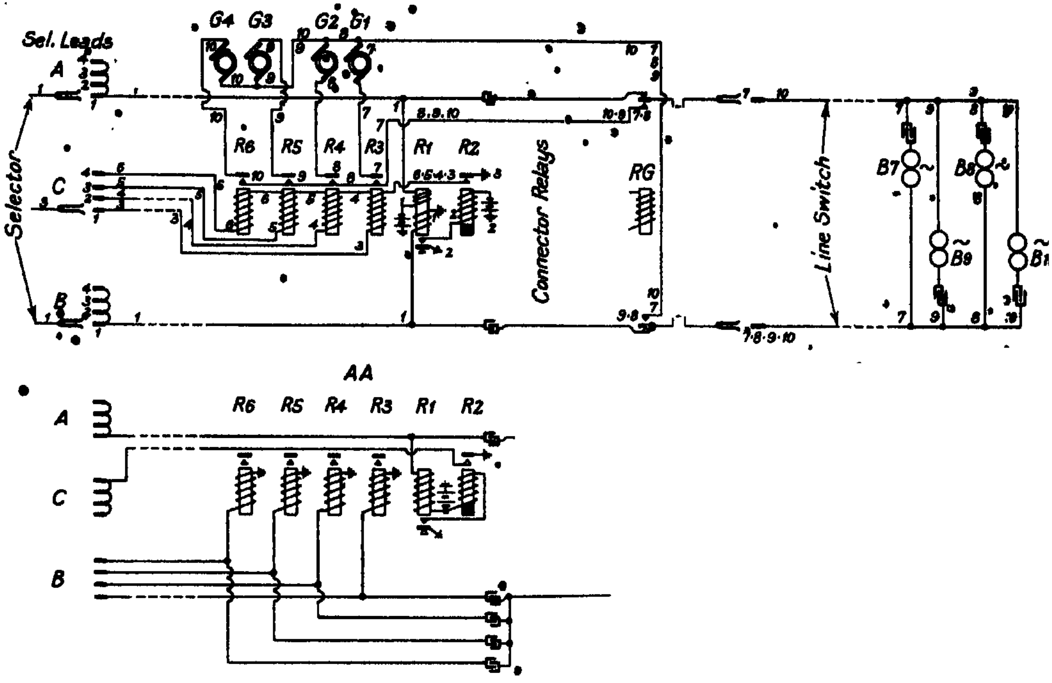
12. Current to called subscriber. R12 energises and reverses the battery towards the caller.

Section 10

PARTY LINES—DISCRIMINATING BY THE SELECTOR

Fig. 25 shows such an arrangement.

The party called depends on the third last digit of the number, which is varied according to the station on the party line. The numbers of the stations on a 4-party line may be,



Alternative Arrangement.

Fig. 25.—Four-party Line Working (A. T. M. Co.). Discriminating by the Selector.

e.g. 124, 224, 324, and 424. On the selector banks the four first terminals of four levels of the A and B line banks must be multipled together for one line, the second terminals for another, and so on. The test terminals are not so multipled, but are individually carried to four relays R3, R4, R5, and R6, one of which is energised according to the level to which the selector wipers have been raised.

The circuits are numbered as follows :—

1. When the selector wipers have made connection with its bank terminals in calling, say 124, relay R′ energises.
2. R2 (slow) energises.
3. R3 energises.
4. If the first digit called had been 2, R4 would energise.
5. If the digit called had been 3, R5 would energise.

6. If the digit called had been 4, R6 would energise.

The ringing-control relay RG is energised as elsewhere described.

7. R3 completes a circuit for G′ over, say, bell B7.

8. R4 completes a circuit for G2 over, say, bell B8.

9. R5 completes a circuit for G3 over, say, bell B9.

10. R6 completes a circuit for G4 over, say, bell G10.

When RG de-energises, the two common circuits are opened.

It will be readily understood that a smaller or greater number of stations on a line may be worked by decreasing or increasing the number of levels, relays, and generators.

An alternative arrangement is shown at AA. Relays R3 to R6 are shown connected to individual terminals of the B line bank terminals.

One relay, according to the level, is energised in series with R′ across the loop to act as a feeder bridge, R′ being now single-wound. A condenser is provided for each terminal. The test terminals are now multipled together and a wire carried to the guarding relay R2 to be earthed.

Section 11

FREQUENCY SELECTOR ADAPTED TO WORK WITH AN ORDINARY CONNECTOR

The special feature of this A. T. M. Co. combination is that the frequency is selected after connection is made to the called line, and by the final digit. An ordinary connector is shown with dotted lines to the frequency switch, where the necessary modifications to the relays and circuits are also shown.

The circuits of Fig. 26 are numbered as follows :—

1. When the calling line is extended to the connector, R′ energises.

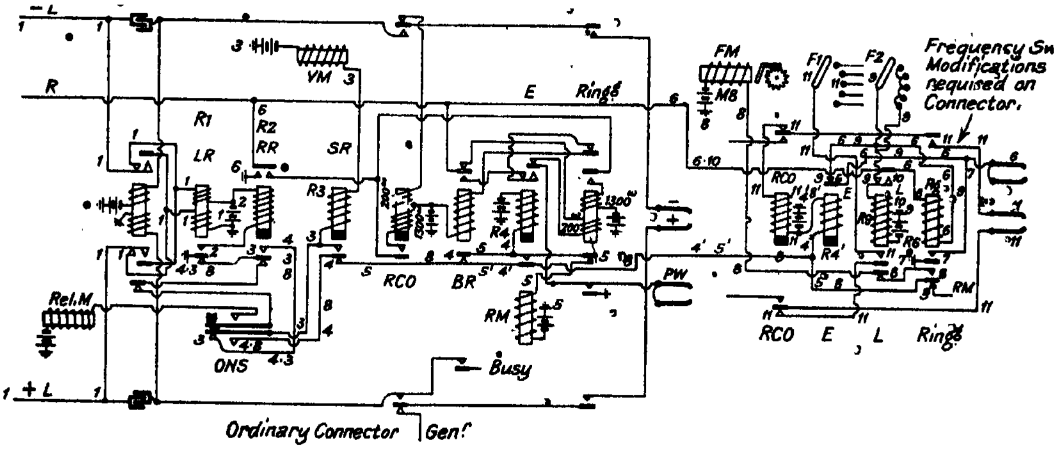


FIG. 26.—FREQUENCY SELECTOR (A. T. M. Co.).

2. R2 (slow) energises.

The tens digit is called.

3. R3 energises for the duration of the impulses. The vertical magnet VM steps-up the shaft.

Units digit called.

4. R4 energises for the duration of the impulses.
5. Rotary magnet RM energises and steps wipers round.
6. If the called line is idle, R6 energises.
7. Called line made busy.

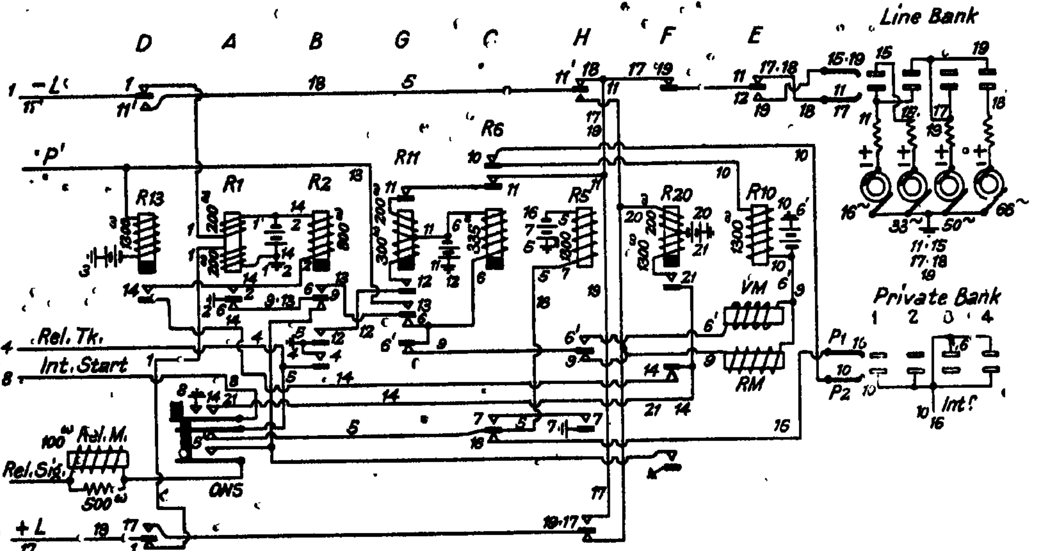
Frequency digit called.

8. Frequency magnet M8 energises to step the wipers F′ and F2 to the corresponding frequency.
9. R9 energises.
10. R9 holding circuit.
11. Required frequency connected to the called line. When the called party answers RCO energises and the lines are connected.

Section 12

PARTY-LINE REVERTING CALL SWITCH

Fig. 27 is one of the latest A. T. M. Co. circuits serving this purpose. No key is necessary at the subscriber's telephone. After dialling the special reverting number, which may be a 4-digit number, if this switch is associated with the second selector, the receiver is replaced to allow the other station on the same line to be called. During the ringing period the guard relay is in the control of a special relay, as the line or impulse-relay is de-energised. The bank terminals may be connected in any particular manner to meet the requirement of the service. The combinations shown are simply by way of example.



Sample Bank Combinations. (Any others may be made.)

1. *Rings 16~ and 33~ bells across the line or both from −Line to earth.*
2. *" 16~ " 50~ " " " " " " " " "*
3. *" 50~ bell on −Line and 50~ bell on +Line (earth).*
4. *" 50~ " " " " 66~ " " " (").*

Fig. 27.—Party-Line Reverting Call Switch (A. T. M. Co.).

The circuits of Fig. 27 are numbered as follows :—

1. By the *first and second digits called* the loop is extended from the first to the second selector and then to this switch, when R′ energises.

2. R2, guard relay, energises.

4. Earth on release trunk.

5. R5 energises.

Second last digit called. R′ de-energises intermittently.

6. R6 energises for the duration of the impulses.

6′. Vertical magnet VM energises in parallel with R6, and steps-up the shaft and wipers. Off-normal switch ONS opens circuit 5.

7. R5 holding circuit for the duration of the impulses.

After the impulses R6 de-energises, then R5.

8. Circuit to INT start.

Final digit called, R′ de-energises as before. R6 energised as before.

9. Rotary magnet RM energises and rotates the wipers to the terminals corresponding to the frequency required.

R6 de-energises after the impulses.

10. If the final digit is 1, R10 energises intermittently.

11. When R10 de-energises the 16∼ circuit is connected to R11, which energises.

12. Circuit through second differential winding to de-energise R11 (slowly).

13. R13 energises so that the caller may replace his receiver, to render the ring back to the called party more efficient.

14. R2 holding circuit while R′ is de-energised.

11′. Frequency circuit 16∼ to called party.

15. When R10 energises 33∼ is connected to line.

If final digit had been 2, 16∼ and 50∼ would be connected to line.

If final digit had been 3, R10 would not be energised.

16. R5 energises to cross over the lines.

17. 50∼ to positive wire (R11 being energised as before).

If final digit had been 4, R10 and R5 would both be energised.

18. 66∼ connected to negative wire when R10 and R5 de-energise.

19. 50∼ connected to the positive wire, when R10 and R5 energise (only the bell tuned will respond, or the caller as well as the called party may be rung).

When the called party answers.

20. R20 energises over negative or positive wire, the circuit being completed over R11 to earth. Wire to the frequency generator is opened.

21. Neutralising circuit R20 de-energises.

R11 de-energises, then R13.

R′ is reconnected to line, and is then in the control of both parties. Current for the microphones is supplied through this relay.

Section 13

REVERTIVE CALLING ON PARTY LINES

A group of party lines has access to two sets of calling-line finders in a W. E. Co. system (Fig. 28), one set being used for ordinary calls and the other for reverting calls only. Each party circuit has two line relays R and R'. R is energised in the loop in the usual way for ordinary calls. R' is differentially wound and only energised for reverting calls, when key K is depressed to earth the B wire. R' controls the reverting finders, each of which is equipped with a ring-back equipment, selectively operated by impulses sent by the caller.

The ringing equipment connects positive or negative current to the A, or to the B, wire, together with alternating current, which energises a relay fitted in the instrument, to connect up the polarised bell. A subscriber desiring to call another party on the same circuit depresses key K', and then removes the receiver.

The circuits are numbered as follows :—

1. Key K' depressed, differential relay R' energises.

2. R2 energises and completes a holding circuit for R', K' released.

When the receiver is lifted, R2 is a shunt about R, so that it does not energise.

3. M3 energises, and the special finders hunt in known manner.

4. Controlling test relay R4 energises.

5. Holding circuit of R4 over INT.

6. When earth removed, R6 energises.

7. Sequence switch M7 moves to position 4.

8. R8 energises, when M7 passes position 3.

9. R9 (COR) energises.

Operation of ringing back.

10. Stopping relay R10 energises.

11. R11 energises.

12. M7 moves to position 8.

13. R13 energises, and opens circuit 11.

14. Register M14 energises. When M14 closes its local contact, R14 energises, and M14 steps into position 1.

15. The second winding of differential relay R14.

16. Interrupter connected to primary of coil, to give dialling-tone to caller.

17. M14 is set by a single group of impulses under control of R14, R17, and R10, in a manner as described in Vol. I.

18. At the last interruption, R10 de-energises long enough for R18 to energise.

19. R19 energises.

20. SS M7 moves to position 11.

The caller then depresses the reverting key K2, thereby introducing a condenser into the loop circuit, and R10 de-energises. R18 again energises, circuit 20 is completed, and M7 moves to position 12, which is the ringing position.

It is assumed that the four ringing positions of the register M14 are 6, 7, 8, and 9.

21. R21 is energised if M14 stops in position 6 or 7.

22. R22 is energised if M14 stops in position 8 or 9.

23. Negative, with superimposed alternating current is connected to the A wire, or

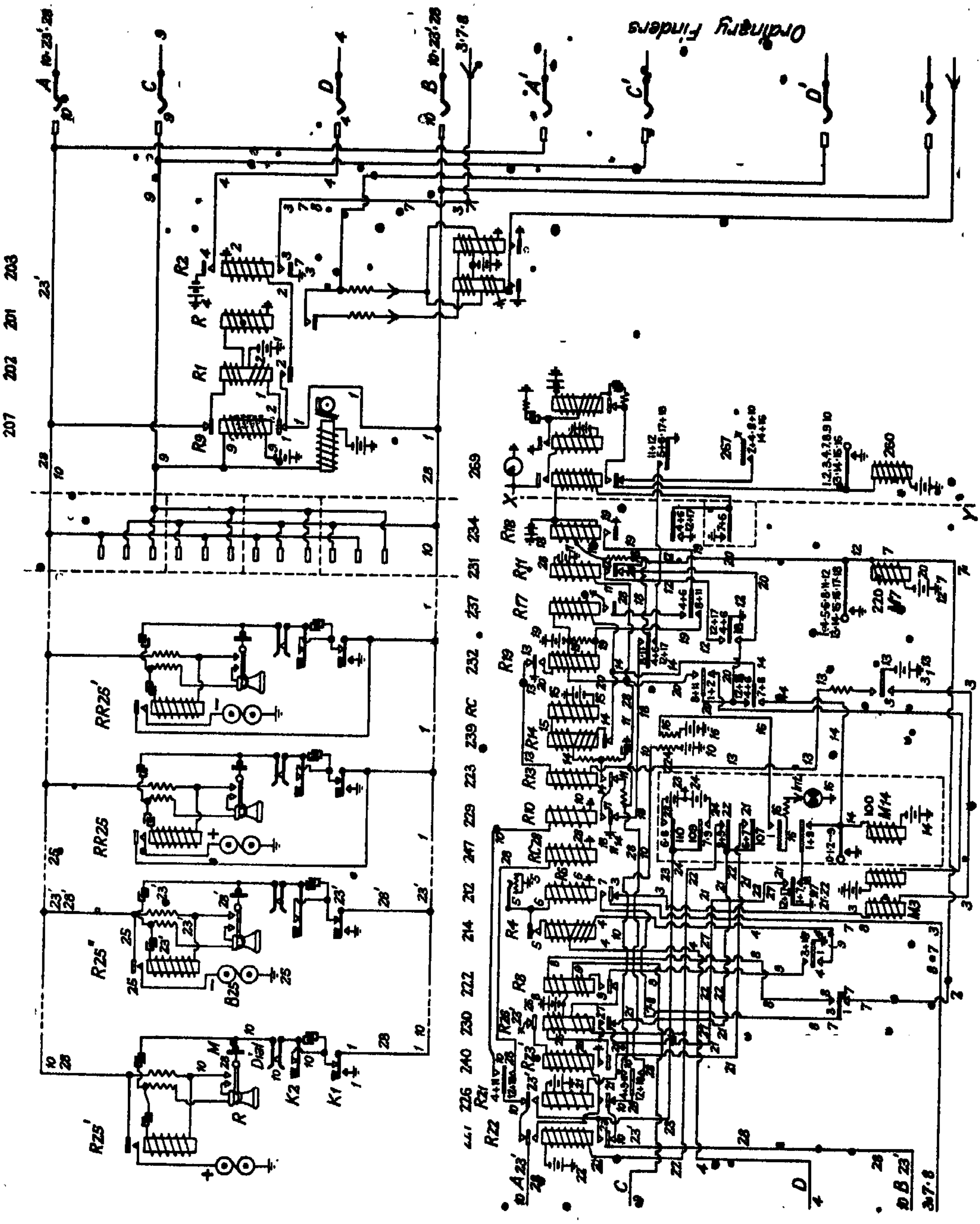


FIG. 28.—ROTARY SYSTEM (W. E. Co.). REVERTING CALLS ON PARTY LINES.

positive, with superimposed alternating, current is connected to the B wire, according as R21 or R22 is energised for positions 6 and 8.

24. The above conditions are reversed for positions 7 and 9. One of the instrument relays (25) energises and connects the polarised bell to line, so that one station only is rung.

25. B25 rings at station R25".

23′. When the receiver is lifted to answer, R23′ energises.

26. R26 energises.

27. R26 holding circuit, R21, R22, and R13′ de-energise.

28, 28′. Current for the microphone is fed over R11 and R28.

SS M7 moves into position 18 (talking position), over circuit 12.

When the receiver is replaced, R11 de-energises and restores the circuit to normal.

The apparatus shown to the left of the dotted line *xy* restores the special finder to normal, if the call is not completed in a pre-determined time, if the called party does not reply, or if two finders simultaneously connect with the calling line. This apparatus is common to a number of finders.

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Section 14

PARTY LINES MULTIPLED OVER A PLURALITY OF GROUPS OF CONNECTORS

Such an arrangement is fairly obvious and no diagram is provided. The groups of connectors are each arranged for 100 lines as usual, and the hundreds digit differs for each group. On a 4-party line the four groups of connectors may be numbered as follows :—(*a*) from 0 upwards ; (*b*) from 100 ; (*c*) from 200 ; and (*d*) from 300.

The same 100-party lines are multipled over the four groups, the latter being suitably connected to different levels of the selector banks. A different ringing frequency is connected to each group of connectors so that each group will call one station on each circuit, namely, that having the bell tuned to respond to the frequency of the associated generator.

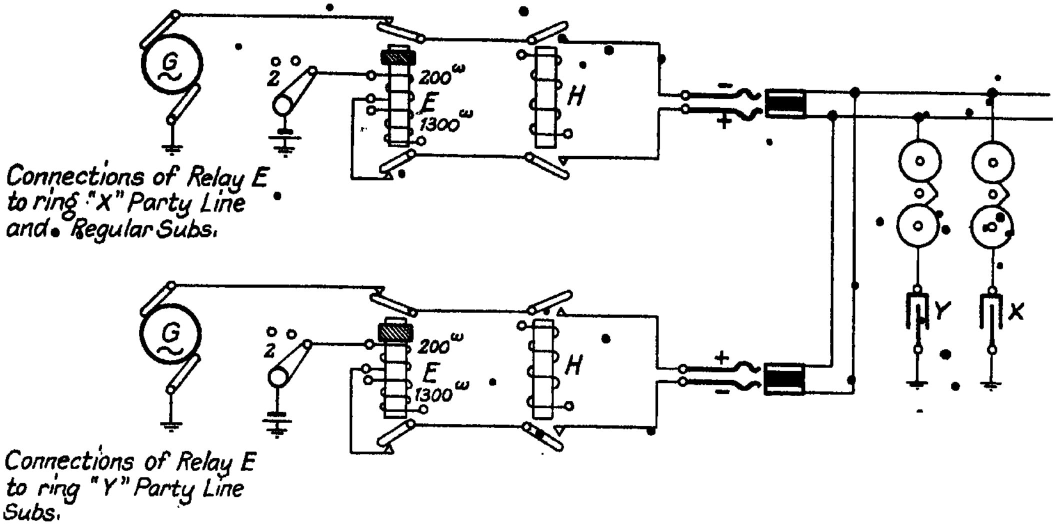
G
2
200ω
E
1300ω
H
−
+
Connections of Relay E to ring "X" Party Line and Regular Subs.
Y
X
G
2
200ω
E
1300ω
H
+
−
Connections of Relay E to ring "Y" Party Line Subs.

FIG. 29.—TWO-PARTY LINE RINGING ARRANGEMENT ON CONNECTORS (A. T. M. Co.).

Post Office Two-Party Lines.—As previously mentioned, only 2-party lines are in use, on automatic systems, in this country, and they are wired on this method. Fig. 29 shows the modification necessary to the A. T. M. Co.'s circuits. It will be noticed that one set of connectors has negative current connected to the upper wiper of a pair, whilst the other set has positive current connected to the corresponding wiper. The former is used to ring the X station, the bell of which is connected through a condenser to earth from the A wire ; the latter is used to ring the Y station which is a tap to earth from the B wire.

Section 15

LOCK-OUT PARTY LINE AND RE-RINGING CIRCUIT

Each party-line instrument has a locking relay associated with it which, when energised, allows a suitably-shaped spring to lock the armature in the operated position, until it is released by the switchhook when the receiver is replaced. The switchhook is so shaped that, when the receiver is lifted, a disc indicator bearing the word *busy* appears at an aperture, should the relay not energise. Should the relay energise, a disc indicator, attached to its armature, will pass between the *busy* shutter and the aperture, indicating that the call has been effective.

When the party line is already busy, and another call is made, the relay will not energise in parallel with the existing shunt. When a call is for another station on the same line the caller must depress a key, to introduce considerable resistance into the circuit, to enable the called party to answer.

Re-ringing is obtained by locking the ringing-trip relay over the impulse relay, so that when another impulse is sent, that relay de-energises and re-connects the ringing circuit.

The circuits of Fig. 30 (A. T. M. Co.) are numbered as follows :—

1. When the receiver is lifted to call, and the line is idle, R′ energises by a momentary current from battery at line switch. The kneeded spring passes behind the armature, to maintain it in the operated position. As the line is idle the word *busy* is obliterated by the armature shutter.

2. Circuit through microphone in which the line switch (not shown) operates in known manner, to extend the calling line to the first selector. Impulse relay R″ and also RR′ energise.

3. Guard relay R3 (slow) energises.

The first digit impulses are sent.

4. The vertical magnet VM steps-up the wipers to a corresponding level, and R4 energises for the duration of the impulses.

5. M5 energises. R4 de-energises after impulses, then M5 and the side switches pass to the second position.

6. The rotary magnet RM energises and rotates the wipers in known manner, to find an idle line. R6 energises for the duration of the search. When R6 de-energises the side switches pass to the third position.

7. The calling loop is extended to relays R7 and R7′, which energise.

8. Holding circuit of line and other switches.

9. R9 (guard, slow) energises.

10. Guarding circuit.

10′. R6, being slow to de-energise, guards circuit 10 until R9′ energises.

Second digit impulses on connector.

11. The vertical magnet energises and steps-up the wipers to the desired level. R11 (slow) energises for the duration of the impulses.

12. R12 energises for the duration of the impulses. After the impulses, R11 and R12 de-energise and the side switches pass to the second position.

Final digit.

13. The rotary magnet RM steps the wipers round a distance corresponding to the

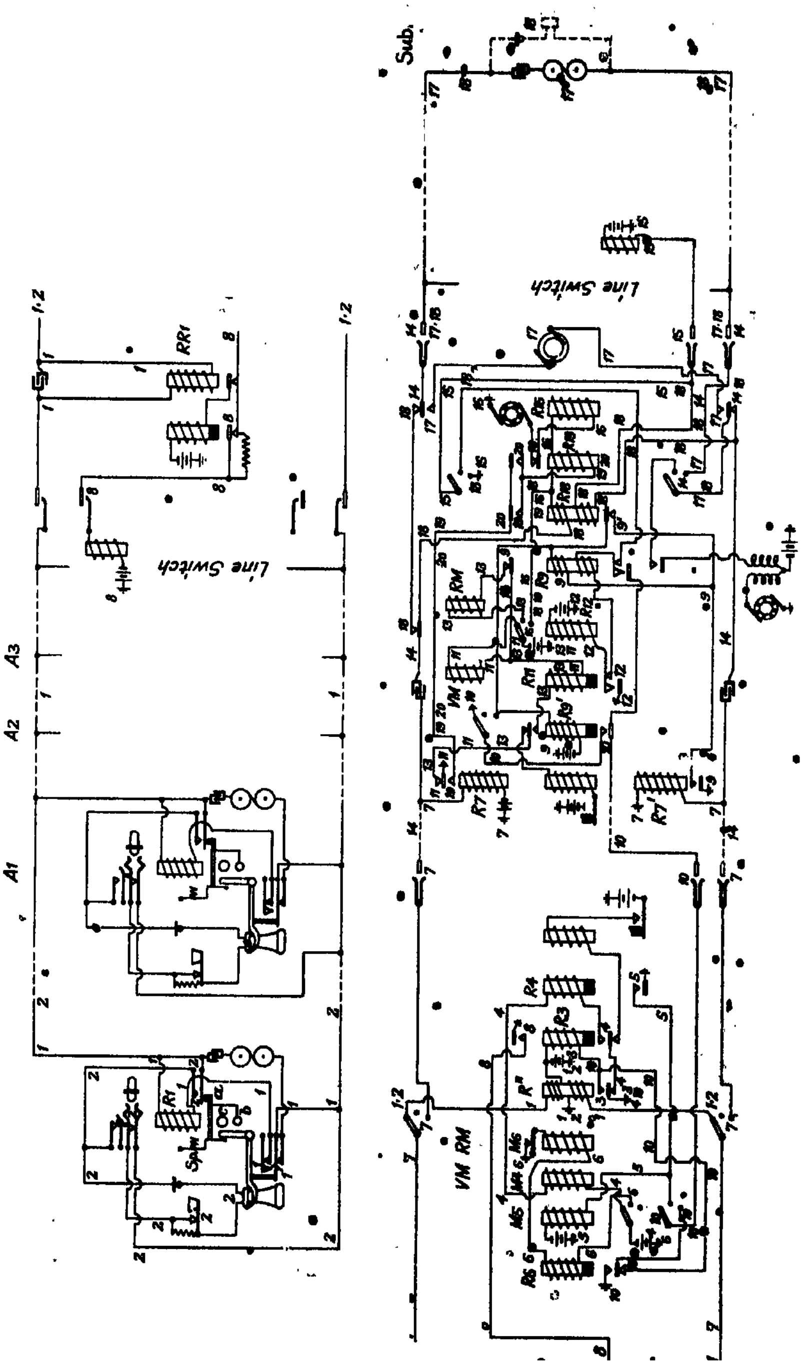

FIG. 30.—LOCK-OUT PARTY LINE (A. T. M. CO.).

digit. R11 and R12 again energise as before and de-energise after the impulses, and, if the line is idle, the side switches pass to the third position.

14. The calling loop is extended to the terminals of the called line.
15. Guarding circuit.
16. Ringing relay R16 energises intermittently over the interrupter.
17. Ringing circuit to the called line.
18. R18 energises when the called party answers (talking circuit).
19. R19 energises to open circuit 16 to cut off ringing.
20. R19 locking circuit, to prevent re-ringing if called receiver replaced.

Should the caller desire to again ring the called party, who may have replaced the receiver prematurely, without clearing and re-dialling the number he may do so.

When the called receiver is replaced R18 de-energises, and R19 is held energised over circuit 20. If now the caller dials R7 de-energises and circuit 20 is opened and R19 de-energises, circuit 16 is again completed to ring the called party. R18 again energises when the called party answers, and R19 again energises to lock.

To call another station on the same party line, the operations and circuits are very similar to those already described.

Section 16

SELECTIVE SIGNALLING ON PARTY LINES

W. E. Co.'s Four-Party Line.—The particular feature of this system is the relay in the instrument, shown in Fig. 31. The armature has a long travel after contact has been made, so that, although the armature may vibrate under the intermittent current, the movement is not sufficient to break the local bell-circuit.

A U-shaped armature, *a*, is pivoted by the two ends to one pole of an electro-magnet which is placed between the limbs. The armature normally lies out of line with the core, but when a current is passed through the coil it is attracted towards the core at the free end. The contact is near the pivoted end.

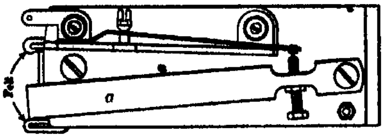

FIG. 31.—WESTERN ELECTRIC CO'S. SLOW-ACTING ALTERNATING AND DIRECT-CURRENT RELAY.

The relay at each station is directly across the loop with a condenser in circuit, and all respond when a current of either polarity is connected to line. The earthed bells are, therefore, only connected to the circuit during the brief period of ringing, and the circuit is therefore a balanced one normally (*see* Fig. 32).

The subscribers' telephones on a party line are bridged across the circuit, the bells being normally disconnected. Each party-line instrument contains a relay in series with a condenser, and when intermittent currents pass through this relay it cuts in the bell either between the A wire and earth or between the B wire and earth. The two bells connected to each wire respond to currents of different polarity. One bell only responds when ringing current is applied to a wire.

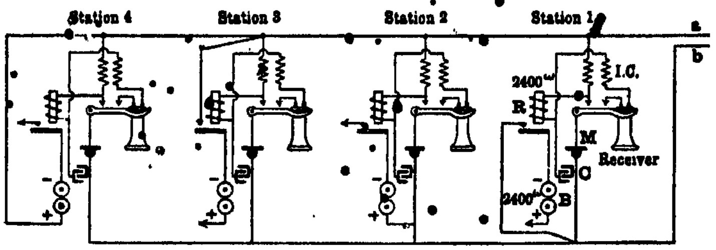

Fig. 32.—Western Electric Co.'s Four-Party Selective Ringing Circuit.

Frequency Party Lines.—The "Leich" selective system of the American Electric Telephone Co. is a *frequency* system. Two frequencies are generally used, one 20 cycle and one 60 cycle. Two bells may be connected to earth from each wire of the metallic circuit, the two on the same wire responding to different frequencies. Advantage is taken of the choking effect of capacity and self-induction in a circuit in relation to the frequency of an alternating current. The 1000-ohm bell of one instrument (Fig. 33) has, therefore, in series with it a 2000-ohm retardation coil and a 2-mfd. condenser, and the bell readily responds to the low-frequency current, but the choking effect of this circuit on the high-frequency current is so great that the bell does not ring. The other instrument (Fig. 34) has a 1000-ohm retardation coil in parallel with the bell and a 0·3-mfd. condenser in series. This bell readily responds to the high-frequency current, but the 0·3-mfd. condenser does not allow the low-frequency current to interfere.

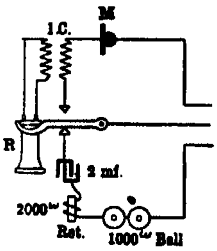

Fig. 33.—Leich Low-Frequency Instrument.

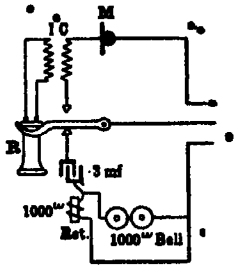

Fig. 34.—Leich High-Frequency Instrument.

The Harmonic Party-Line System.—After work in this direction by Currier and Rice in 1880, and Lighthipe at a considerably later date, W. W. Dean, for the Kellogg Company, further developed this system about 1903, and, after forming the Dean Electric Co., greatly modified and improved this in 1905. Mr Dean set himself the task of designing a party-line system without earth connections, "no relays or adjustable springs, no step-by-step mechanism, and that the ringing of the bells should not be appreciably affected by either the resistance or capacity of the line." This system is based on the principle that every pendulum or reed has a natural period of vibration. Each ringer or polarised bell has the rod carrying the hammer attached to the armature, which in turn is attached to the frame or mounting by a short flexible spring (Fig. 35). The hammers of the four bells used on one circuit are of varying lengths, so that each has a different rate of vibration (Fig. 36). The four bells are connected directly across the loop with a 1 mfd. condenser in series (Fig. 37). One bell will respond to 16⅔~, another to 33⅓~, the third to 50~, and the fourth to 66⅔~. In other systems, 20, 30, 42, 54, and 66 cycles per second are used with five stations on a line. An 8-party line selective circuit may be formed by connecting four such instruments from the A wire to earth and another four from the B wire to earth.

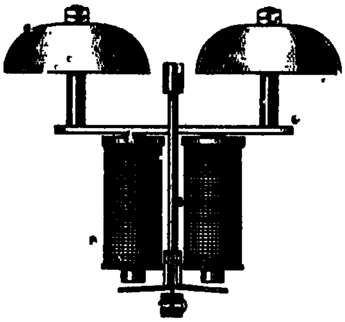

Fig. 35.—Dean Harmonic Ringer. Normal Position of Armature.

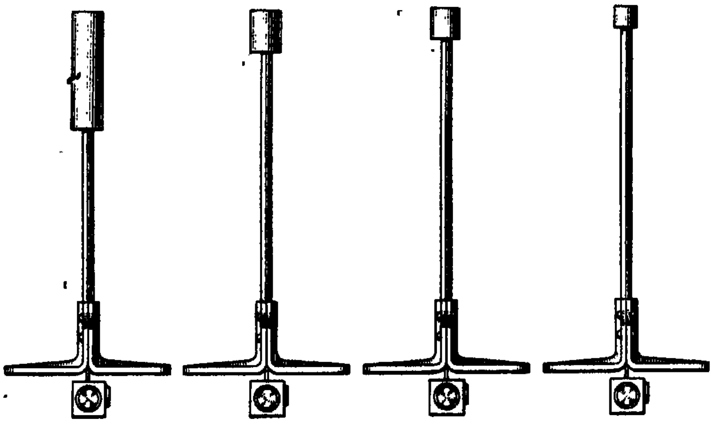

Fig. 36.—Dean Harmonic Ringer Armatures.

A multi-cycle motor-generator may be used to give the different frequencies, but the Dean Electric Co. now recommend their "harmonic converter" as being more reliable and

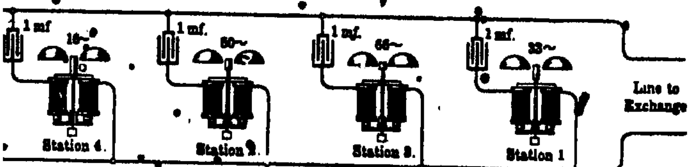

FIG. 37.—DEAN HARMONIC PARTY LINE.

much more economical. This consists of four pole changing vibrators, each with a transformer and condenser to give the four frequencies. As will be seen from Fig. 38, the vibrator has a trembler bell action. On attraction and release, the springs make with different contacts and allow of currents opposite in direction passing through the transformer. The rate of vibration of the armature movement is controlled by mechanical means similar to those used in the bells. The converter, when run from the 24-volt battery, takes 0·28 ampere, and when ringing on a 4-party line this no-load current is doubled. Where it is necessary to economise still further in current consumption the converter may be controlled by a relay which brings it into use only when a key is depressed. The current taken is then 24 milli-

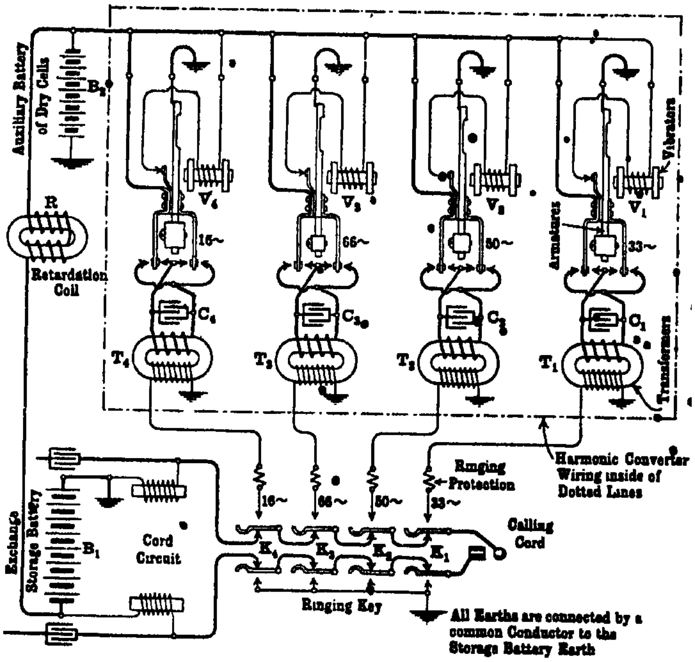

FIG. 38.—THEORETICAL CIRCUIT OF DEAN 5-CONTACT TYPE HARMONIC CONVERTER, SHOWING THE CONNECTIONS TO THE STORAGE BATTERY OF A COMMON BATTERY EXCHANGE.

amperes. In large exchanges it is kept continuously running. This apparatus is also designed for running from primary batteries.

When run from the speaking battery a " noise killer " is introduced. This consists of a high impedance coil R (Fig. 38), and a battery of dry cells, B^2. The former is placed in the supply lead between the battery and the converter, and the latter a tap to earth nearer the converter. This is connected with the negative pole to line and positive to earth, *i.e.* similar to the central battery. This primary battery is kept constantly charged by the main battery, and absorbs all the noisy back surgings that would otherwise disturb the whole system.

For frequency or harmonic systems it is most important that the ringing currents be correct, so that there is no interference or causing bells at stations (other than that called) to be sounded. The Union Electric Co. (London) have put on the market the Hartmann-Kempf frequency meter, which is a direct indicating electro-acoustic instrument, with vibrating steel reeds arranged consecutively as a scale.

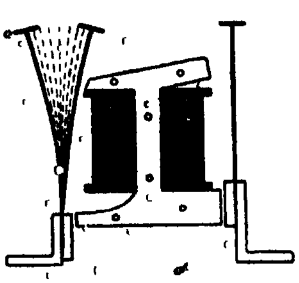

FIG. 39.—HARTMANN-KEMPF FREQUENCY METER.

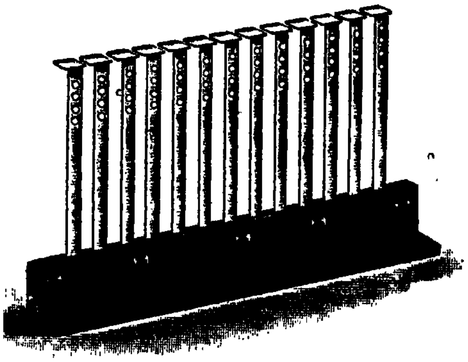

FIG. 40.—HARTMANN-KEMPF FREQUENCY METER.

The general arrangement of the instrument depends upon the purpose for which they are required. They are made up from a number of steel reeds, all of varying but permanent vibration rates. If a steel reed of this description is acted on by magnetic impulses, it vibrates, but only when a resonance action between its own vibration rate and the frequency of the magnetic impulse occurs. This vibration is rendered distinctly visible from considerable distances by attaching a small white tip to the steel reed (Figs. 39 and 40).

The vibrating reed corresponds, therefore, to the deflection of a pointer instrument.

As any periodic vibration will induce resonance in the reeds, it is a matter of indifference whether the magnetic field is produced by alternating current, or by interrupted direct current, or by periodic movement of magnets. Instruments with their reeds arranged as a scale can therefore be used as frequency meters for alternating and interrupted direct current, tachometers, and speed indicators for either direct or distant control. The circuit arrangements correspond to those of a voltmeter.

Fig. 41 shows the frequency meter used on the Dean system. The four groups of five reeds of each series contain one reed for the standard frequency and two reeds calibrated closely thereto. Each separate set is for a different frequency — viz. 16⅔, 33⅓, 50, and 66⅔.

It is well known that in acoustics partial tones arise when the base tone is loud, and with

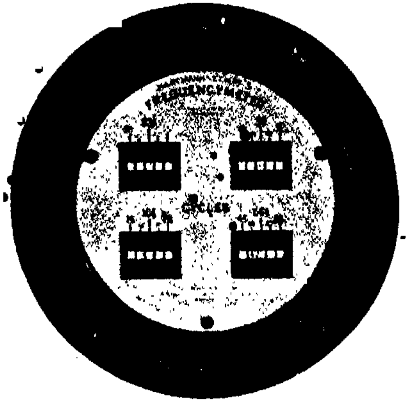

FIG. 41.—HARTMANN-KEMPF FREQUENCY METER.

resonance-frequency meters the same action arises. For this purpose special circuit conditions and arrangements are adopted which only admit of the actual prevailing frequency being indicated in this apparatus. Small variations from the standard frequency are shown by the four other reeds in the group. The accuracy with which frequency can be adjusted on the master reed is extremely high, approximately 1 per mille.

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SUBSCRIBERS' OFFICES
DISTRICT STATIONS
BRANCH OFFICES
MAIN OFFICE SWITCHES FOR ABOVE
PRIVATE INSTALLATIONS
VILLAGE EXCHANGES
COMMUNITY EXCHANGES

DIRECTOR OF INDUSTRIES.
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Section 17.

SMALL SWITCHBOARDS FOR SUBSCRIBERS' OFFICES

The provision of equipment in subscribers' offices that will not reduce the operating or transmission efficiency of the main system, but will co-operate with it as a fundamental part, has been one of the great problems of automatic telephony.

These installations, as a rule, are comparatively small—the bulk being under fifteen lines capacity. In most of the small offices no regular operator is provided, so that the service tends to be of an inefficient character, and, just as the strength of a chain is that of its weakest link, so the efficiency of a multi-office telephone system may be marred or greatly reduced by these small exchanges.

These switchboards have to provide for interconnecting the offices of a business, but have also to connect these offices to other subscribers on the main system, for outgoing and incoming calls. The connection may be over extension telephones in each case, when, unless great care is taken, the main service may be prejudiced. As the clearing or disconnecting is initiated at one telephone, if the receiver is not replaced promptly, the plug withdrawn, or the key restored to normal, then one or more trunks or junctions may be held idle for an unnecessarily long period.

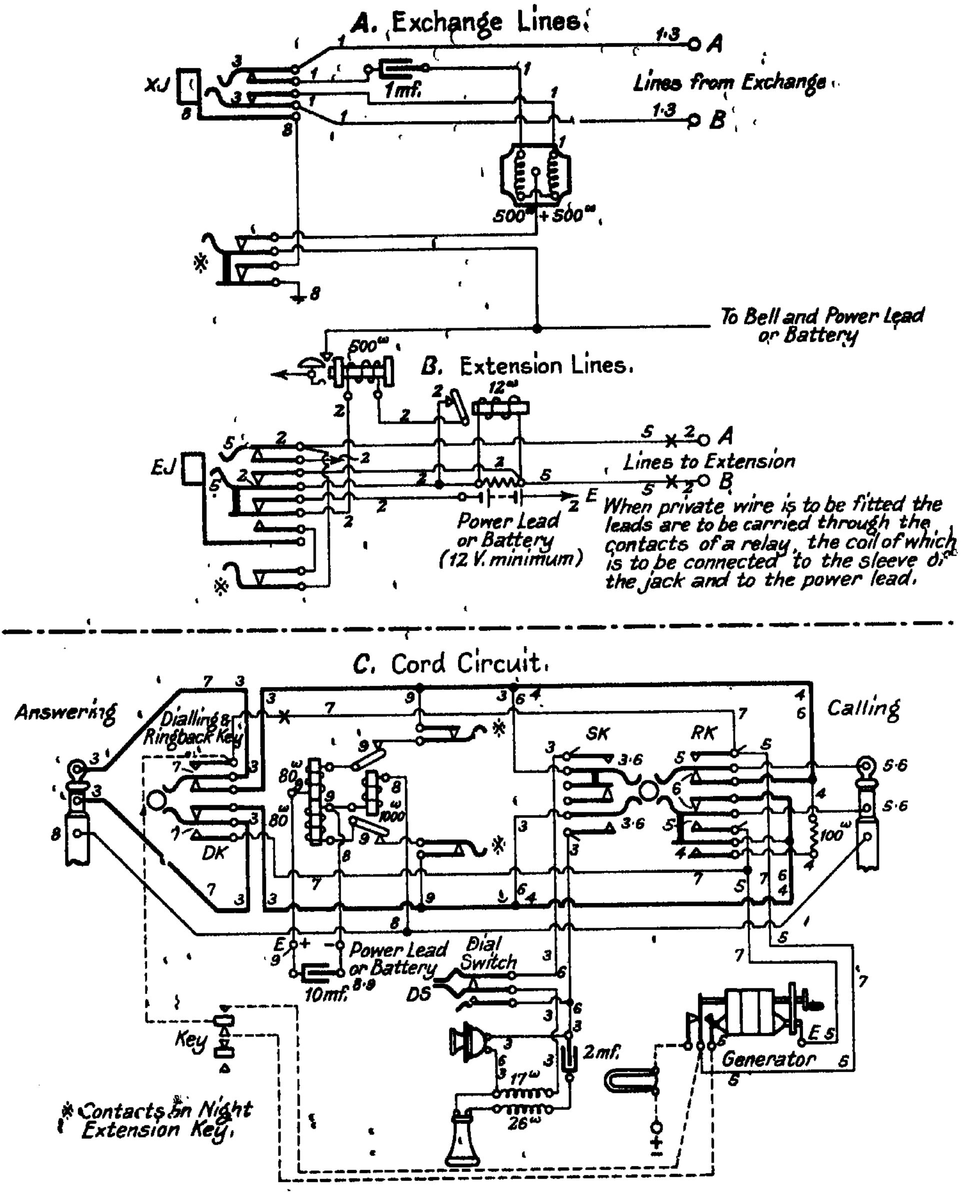
Additional trunks may thus be rendered necessary, thereby adding to the cost of the system, or an inferior service must be given.

From the Public Service point of view, these small installations should be entirely automatic in operation. The release of a connection through the main office would then be instantaneous when the receiver was replaced, and the transmission efficiency would be first class.

The Post Office have modified certain small switchboards, formerly used on common battery manual systems, to automatic working.

The principal modification consists in providing an impulse-dial in connection with the cord circuits, so that outward calls can be originated at the switchboard. As the battery bridge is cut off the cord circuit, when an extension is through to the exchange, dials may also be fitted on extension instruments when required.

Fig. 42 shows such a Post Office circuit for switchboards up to 25 lines capacity. At A is shown the exchange line circuit, at B the extension line circuit, and at C the cord circuit.


A. Exchange Lines.
XJ
1mf.
Lines from Exchange
1·3 A
1·3 B
500ω + 500ω
To Bell and Power Lead or Battery
500ω
B. Extension Lines.
12ω
EJ
Lines to Extension
5 2 A
5 2 B
E
Power Lead or Battery (12 V. minimum)
When private wire is to be fitted the leads are to be carried through the contacts of a relay, the coil of which is to be connected to the sleeve of the jack and to the power lead.
C. Cord Circuit.
Answering
Dialling & Ringback Key
DK
80ω
80ω
1000ω
SK
RK
Calling
100ω
E
Power Lead or Battery
Dial Switch
DS
10mf.
2mf.
17ω
26ω
Key
Generator
*Contacts on Night Extension Key.

Note :- To call an Exchange No. the operator will keep the Answering Plug in the Extension Jack, throw Listening Key, press Dialling and Ring-back Key associated with the Answering Cord in use, and dial Exchange No. To ring back keep the Listening Key thrown whilst operating the Dialling and Ring-back Key. When Power Ringing is supplied the connection between the "Ringing" and "Dialling and Ring-back Key" marked X, associated with each Cord Circuit should be disconnected and a Key fitted locally which will be wired as shown by the dotted connections. This will be known as the Power Ring-back Key and will be operated when it is desired to ring back on any Answering Cord.

FIG. 42.—P.O. SMALL SEMI-AUTOMATIC SWITCHBOARDS FOR SUBSCRIBERS' OFFICES.

The circuits are numbered as follows :—

1. The calling circuit from the exchange on a drop indicator.

2. Calling line from an extension on a battery indicator.

3. A central call is answered by the answering plug being inserted in the jack XJ when the speaking key is operated, to connect up the attendant's telephone, and the call indicator and condenser are cut off. After learning what extension line is wanted, the calling plug is inserted in the extension line jack EJ and the key moved to the ringing position.

4. A holding circuit is then established to prevent any exchange switches being restored to normal. The 12-ohm relay energises when the telephone is in circuit and also in this circuit. This cuts off the line indicator.

5. Ringing circuit for hand generator.

When the called party answers the connection is through from the extension to the central and the switchboard attendant's telephone is in parallel. The key SK is placed to normal. The 12-ohm relay has a non-inductive shunt in parallel, and these are in series in the talking circuit.

Should the call be from an extension telephone for the central, the answering plug will be inserted in the jack EJ, and the short-circuit about the 12-ohm relay and shunt opened, so that the relay energises from the local battery and cuts off the line indicator. Circuit 5 of the extension line is extended to the attendant's telephone over circuit 3. The calling plug will be inserted in the jack XJ and the speaking key SK and the dialling key DK be operated. The latter opens the circuit to the extension.

6. Circuit 3 of the exchange line will be extended by circuit 6 to the attendant's telephone. The attendant will dial the number wanted by the impulse-dial DS, the switchboard receiver being short-circuited as usual during impulsing.

7. When the called party answers, the extension line bell is rung by the hand generator, the dialling key still being depressed, if the calling party has not remained at the telephone.

Current for the extension microphone is drawn over the exchange line. For local connections, a local battery may be connected at the terminals marked + and −, or a battery feeding line may be used from the central and connected to the same terminals. The 10-mfd. condenser is then a shunt across the battery to prevent overhearing or other disturbance.

8. When a connection is between the exchange and an extension, the local battery is cut off as relay R8 is energised and opens the circuit to the cord conductors.

When the extension receiver is replaced, the 12-ohm relay de-energises and the indicator is connected in circuit as a clearing signal. This indicator being across the loop, the central apparatus is not released until the plug is withdrawn.

9. For a local connection there is no wire to the bush of the jacks, and, therefore, the relay is not energised, and battery is fed to the cord conductors through the 80-ohm windings to a retardation coil.

When ringing current is supplied over a special lead from a power-driven source, the circuit is modified, as shown in dotted lines and as described on the diagram.

Section 18

SMALL SWITCHBOARDS FOR SUBSCRIBERS' OFFICES, CAPACITIES FROM 25 TO 60 LINES

Fig. 43 shows another Post Office modified common battery circuit for another range of equipments. A drop indicator, such as shown in Fig. 44, is associated with the exchange line, and an eyeball indicator (Fig. 45) is associated with each extension line. For the cord circuits the supervisory signals are of the W. E. Co. disc pattern, which gives a negative signal, remaining energised during conversation. The latter are in series in the B conductor of the cord. An 80 plus 80-ohm retardation coil is bridged across the cords, with a relay in the third conductor, to cut off the local battery when the connection is between the exchange line and an extension, another 200-ohm retardation coil then being connected in series in the bridge to increase the resistance and inductance. When the connection is between two extension lines current is fed from the local battery through the 80 plus 80-ohm windings, there being no third conductor connected to the bushes of these jacks.

In the diagram A is the exchange line, B the extension line, C the cord circuit with impulse-dial.

The circuits are numbered as follows :—

1. Calling from central on exchange line.
2. Extension line calling the branch office.
3. Attendant answers the exchange call, answering plug in jack XJ.
4. Relay R4 energises and cuts battery off cord circuit.
5. Attendant rings the extension line.
6. Through connection.
7. Bridge across talking circuit, 80 plus 80 plus 200 ohms. This is connected between the supervisory signals S3 and S3′.

When the extension receiver is replaced, S3′ de-energises and gives a negative signal to clear. When the answering plug is withdrawn a clearing signal is given to the central.

2. If the call is from an extension line to an automatic central, the extension receiver is lifted and the indicator is displayed.

The answering plug is inserted in jack EJ when the indicator is cut off. Circuit 6 from extension telephone to jack EJ, then circuit 3 from answering plug to attendant's telephone are completed.

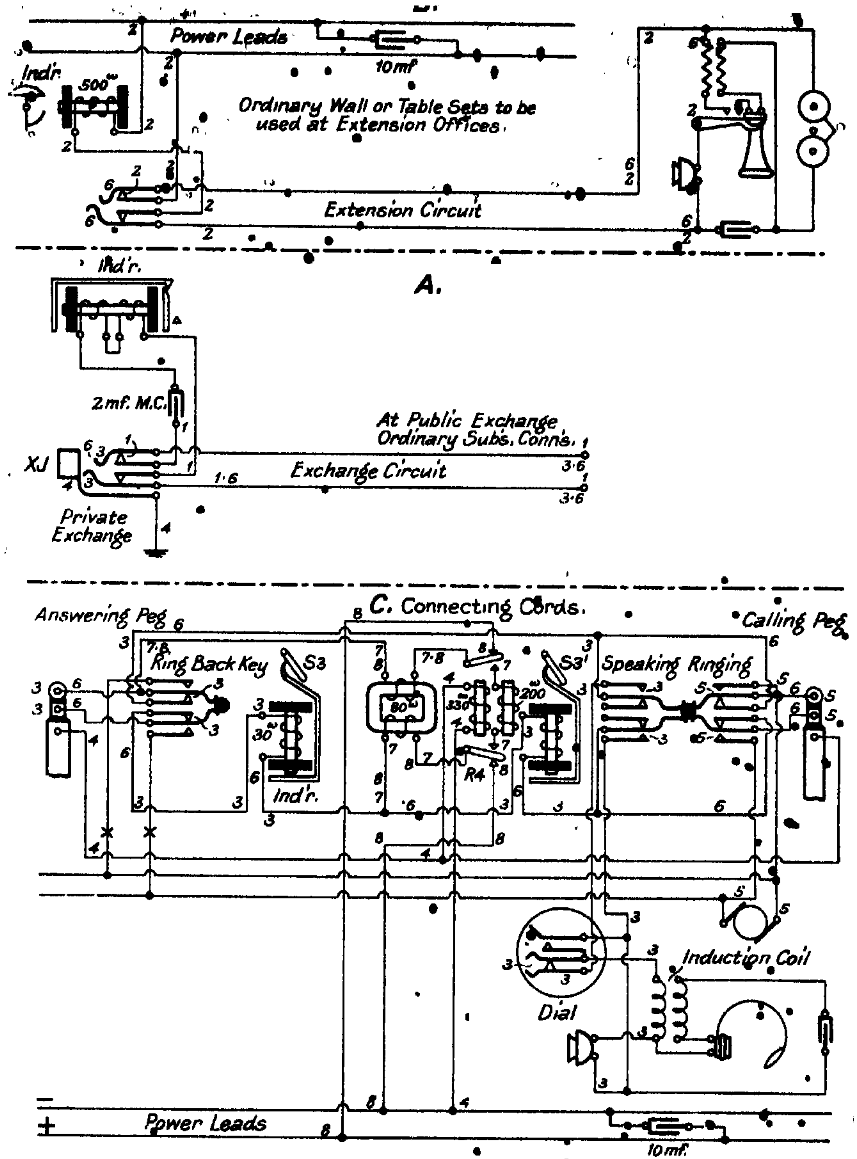
8. Battery bridge across cords, there being no connection to the bush of jack EJ. Signal S3 energises.

Calling plug inserted in jack XJ and indicator cut off. Circuit 4 completed and relay R4 energises to cut off battery (circuit 8). Bridge circuit 7 completed as before.

The ring-back key is operated to open the line to the extension (circuit 3). The impulse-dial is manipulated to call the central line. The speaking key may then be moved to the through position so that the caller may hear the reply, or, if he has left the telephone, he is recalled by the ring-back key. Circuit 6 is then completed.

When one extension line calls another, there is no bush connection on either jack, and current is fed to the talking microphones over circuit 8. Each line controls a clearing signal.

The extension lines should be of approximately equal length so that all microphones get equal current.



Note.— To call an Exchange Nº the operator will keep the Answering Plug in the Extension Jack, throw Listening Key, press Dialling and Ring-back Key associated with the Answering Cord in use, and dial Exchange Nº. To ring-back keep the Listening Key thrown whilst operating the Dialling and Ring-back Key. When Power Ringing is supplied the connections between the "Ringing" and "Dialling and Ring-back Key" associated with each Cord Circuit should be removed and the Ringing Contacts of the latter keys commoned to a key which will be fitted locally and wired as shown in Fig. 46 in dotted lines. This will be known as the "Power Ring-back Key" and will be operated when it is desired to "ring-back" on any Answering Cord.

FIG. 43.—P.O. SEMI-AUTOMATIC SWITCHBOARDS, 25 TO 60 LINES CAPACITY.

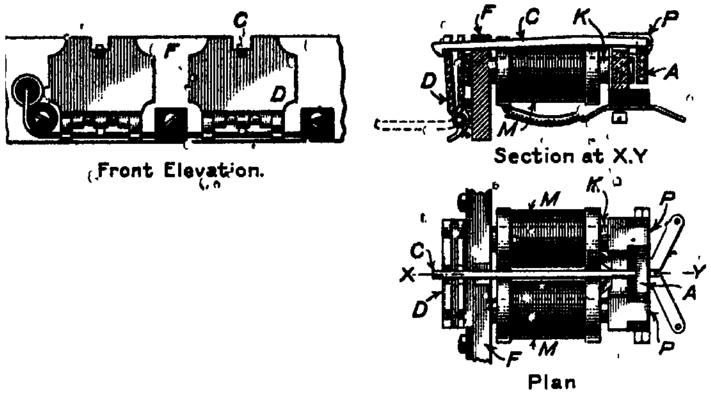
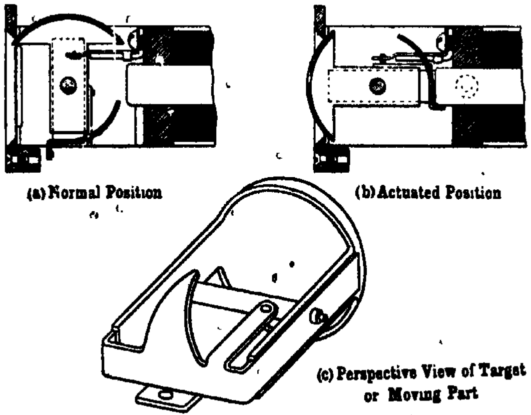


FIG. 44.—TWO-COIL LINE INDICATORS.


(a) Normal Position

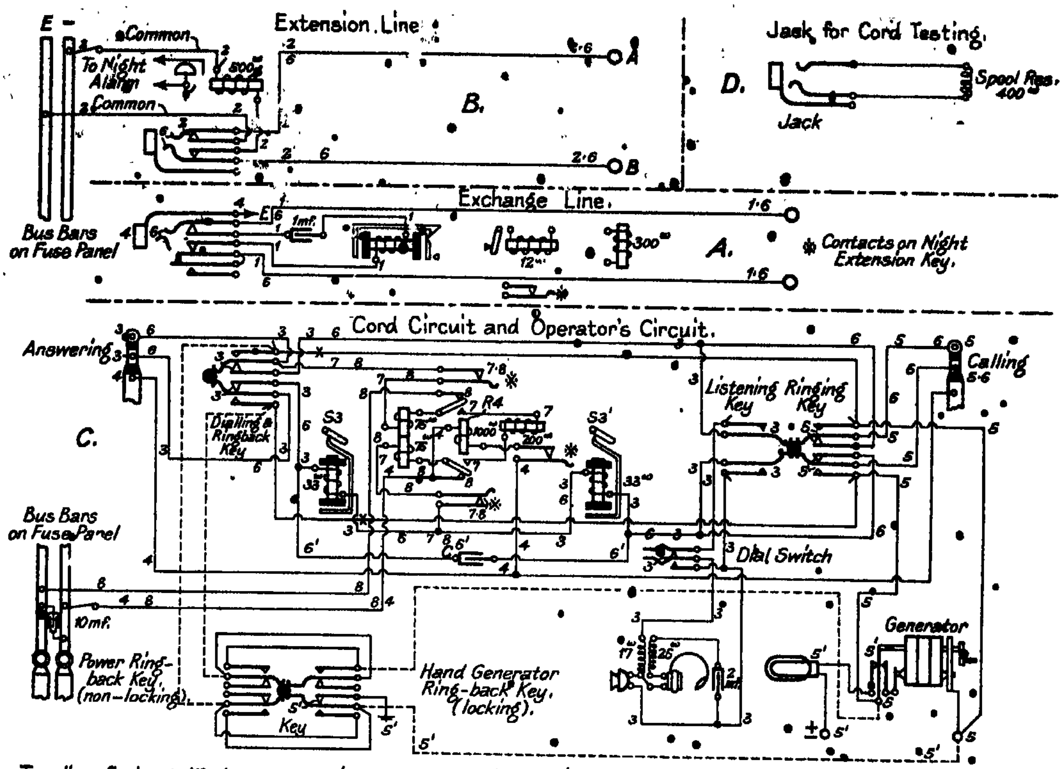
(b) Actuated Position

(c) Perspective View of Target or Moving Part

FIG. 45.—W. E. Co's. (DEAN'S PATENT) EYEBALL INDICATOR.

Fig. 46 shows a somewhat similar circuit for switchboards up to 65 lines. In this, however, a condenser is fitted in the B conductor of the cord to shunt the supervisory signals S3 and S3′, so as to improve the transmission, and to make the battery feed more suitable for lines of unequal lengths. More detail is also given of power-ringing circuits.

The circuits are numbered to correspond with the previous one.



To call an Exchange No. the operator will keep the answering plug in the Extension Jack, throw Listening Key, press Dialling and Ring-back Key associated with the answering cord in use, and dial Exchange No. To ring back, keep the Listening Key thrown whilst operating the Dialling and Ring-back Key. When Power Ringing is supplied the connections marked with a X should be disconnected and a key fitted locally and wired as shown in dotted lines.

FIG. 46.—P.O. SEMI-AUTOMATIC SWITCHBOARD FOR SUBSCRIBERS' OFFICES UP TO 65 LINES.

Section 19

CORDLESS SWITCHBOARDS

Post Office Cordless Branch Switchboards, having a capacity of ten lines.—There are two patterns of these, one having negative clearing signals and the other positive signals.

Fig. 47 shows the circuits of cordless boards with negative clearing signals. The diagram shows three connection-circuits, and these can be increased to five: one exchange line, one extension line, and one main or attendant's telephone circuit. Three exchange lines and seven extension lines is the usual capacity. Each exchange line has as many switches K′ as there are connection-circuits, and one holding key. Each extension line has as many keys K5 or K6 as there are connection-circuits, and a ringing key K4. The attendant's telephone has as many keys K2 as there are connection-circuits. Usually twin keys are used, two being thrown upwards for one connection-circuit and down for another connection-circuit. The main or attendant's telephone set is equipped with an impulse-dial for calling subscribers in an automatic central, both for the main office and for extension lines. Current is supplied for all exchange connections over the exchange line. Current for extension line connections is supplied from a local battery or special feeder leads from a central.

At A is shown the circuit for an exchange to extension-connection. At B is shown the circuit for a connection between two extension lines. At C is shown the switchboard connections.

The circuits are numbered as follows :—

1. Calling circuit from central on drop indicator in branch exchange.
2. Calling circuit from extension, calling branch office on battery indicator.
3. Attendant answers exchange call. Keys K′ and K2 operated.
4. If an extension line is wanted, K4 is operated and the extension rung.
5. When extension answers, K5 is operated to join the lines through. Supervisory signal S3 is energised and is shunted by a condenser. Current is from the central battery.

Should the attendant simply desire to ask a question to pass on to the central caller, the holding key K3 would be operated to bridge the exchange loop with a 750-ohm retardation call.

If the call is from an extension line, indicator C2 energises.

6. Keys K6 and K7 are operated to answer, and attendant learns the caller's requirements.

7. The key of the other extension line, corresponding to K4, is operated to ring that party, and then the key corresponding to K6 is operated to join the connection through, K7 then being released.

8. Battery feeding bridge of 85+85-ohms retardation coil and supervisory coil S8 in series. The latter is shunted by a condenser.

Current is drawn over power leads or from a local battery.

Fig. 48 shows the connections of cordless boards with positive clearing signal. The circuits and operation are generally similar to those in Fig. 47. The supervisory signal is replaced by a relay which is energised in the connection, and when de-energised, on the

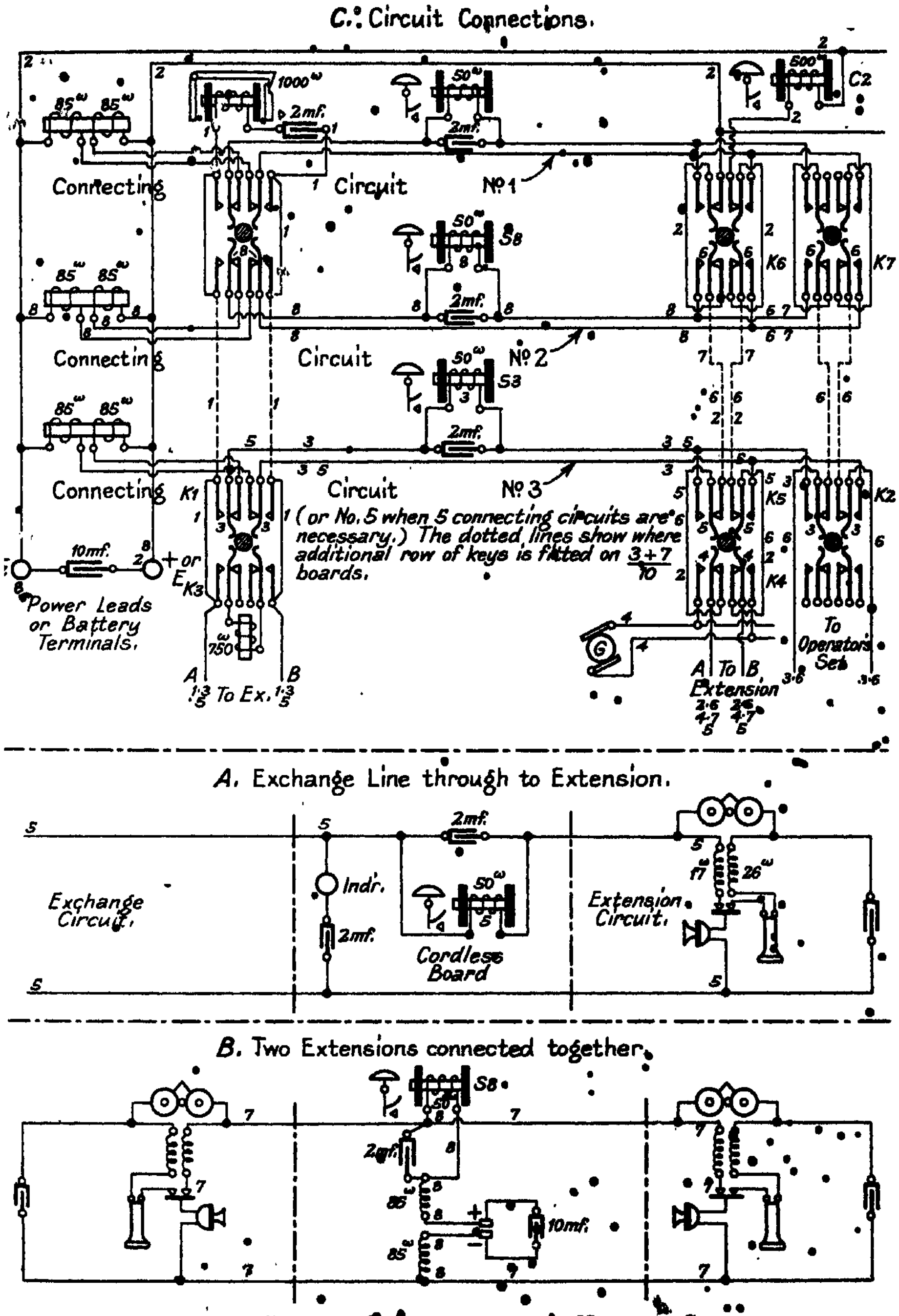
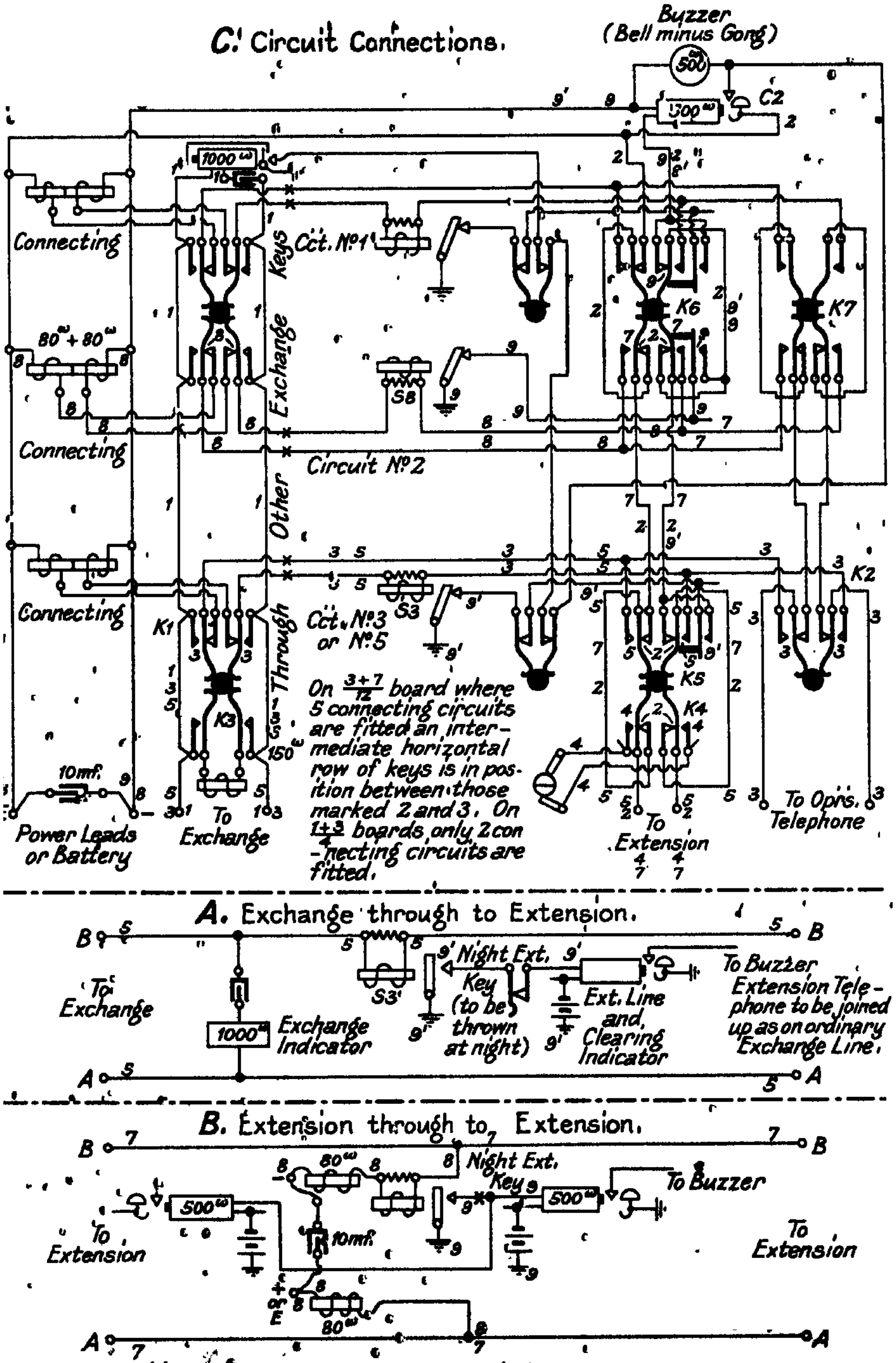


Fig. 47.—P.O. Cordless Switchboards with Negative Clearing.



On $\frac{3+7}{12}$ board where 5 connecting circuits are fitted an intermediate horizontal row of keys is in position between those marked 2 and 3. On $\frac{1+3}{4}$ boards only 2 connecting circuits are fitted.

FIG. 48.—P.O. CORDLESS SWITCHBOARDS WITH POSITIVE CLEARING SIGNALS.

two parties clearing, joins up the line signal (of the extension line in the case of an exchange-extension connection and that of the caller in the case of two extension lines connected) to act as a clearing signal. The relay S3 or S8 (with non-inductive shunt) is energised during conversation.

9. Positive clearing signal on indicator C2 when both extensions clear and S8 de-energises.

9′. The clearing circuit is similar when the exchange is through to an extension.

Section 20

BRANCH AND OTHER SMALL OFFICES

These are variously known as District Offices, Branch Offices, Satellite Offices, Community Exchanges, Private Branch Offices (sometimes P.A.X., to distinguish these from manual offices which are usually called P.B.X.).

Branch offices are a highly-specialised part of an automatic system, and considerable thought and care has to be given their design so that they may not reduce the efficiency of the exchange system. As shown in Fig. 49, an exchange system has almost invariably a number of these satellites surrounding each central office.

They frequently form integral parts of the main system, and at other times they are tagged on.

District offices are frequently satellites to a manual system, when they act as feeders and bring into a larger office groups of lines from an outlying part of the area. Such an arrangement is economical in outside plant, because ten lines to the central office only will be necessary instead of 100 that would be required if all lines were carried directly to the central. In fact these district offices are often cut in on a few existing circuits, which then form trunks, when, owing to some new local condition, a considerable increase of subscribers' lines is to be expected, and perhaps the pole route or existing cable is insufficient to accommodate them.

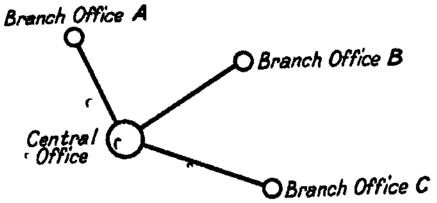


FIG. 49.—CENTRAL OFFICE WITH SATELLITE OR BRANCH OFFICES.

In Fig. 50 is shown a number of ways of working these offices, the adoption of any one depending on the local conditions and the plant available. Many of the features are also applicable to larger offices, particularly during a transition period, or owing to unusual requirements.

Semi-automatic working.—According to Fig. 50, the subscribers' lines of A are connected to the plunger parts of line switches LS, the banks of which extend to the wiper parts of selectors at the central. The subscribers' instruments are fitted with dials, so that by lifting the receiver a line is extended to the central, and by dialling a given number the caller can obtain automatic connection with any line on the exchange. The subscribers' lines are also connected to jacks, and, by the use of plug-ended cords, local connections are obtained. The incoming trunks end on plugs (or may end on jacks). At the central these trunks are multipled on rotary connectors so that a central subscriber, or operator, can, by calling the associated number, select an idle trunk to this branch office. A glowing lamp will indicate a call, and the plug be inserted into the jack of the line called.

Such an arrangement is frequently desired in a private office, because the operator can control the inward traffic and distribute it effectively. She can thus prevent undesirable calls from being put through to the principal, and give alternative connection when a particular party is busy, and the like.

At B is shown an arrangement almost the reverse of that in A. The subscribers' lines

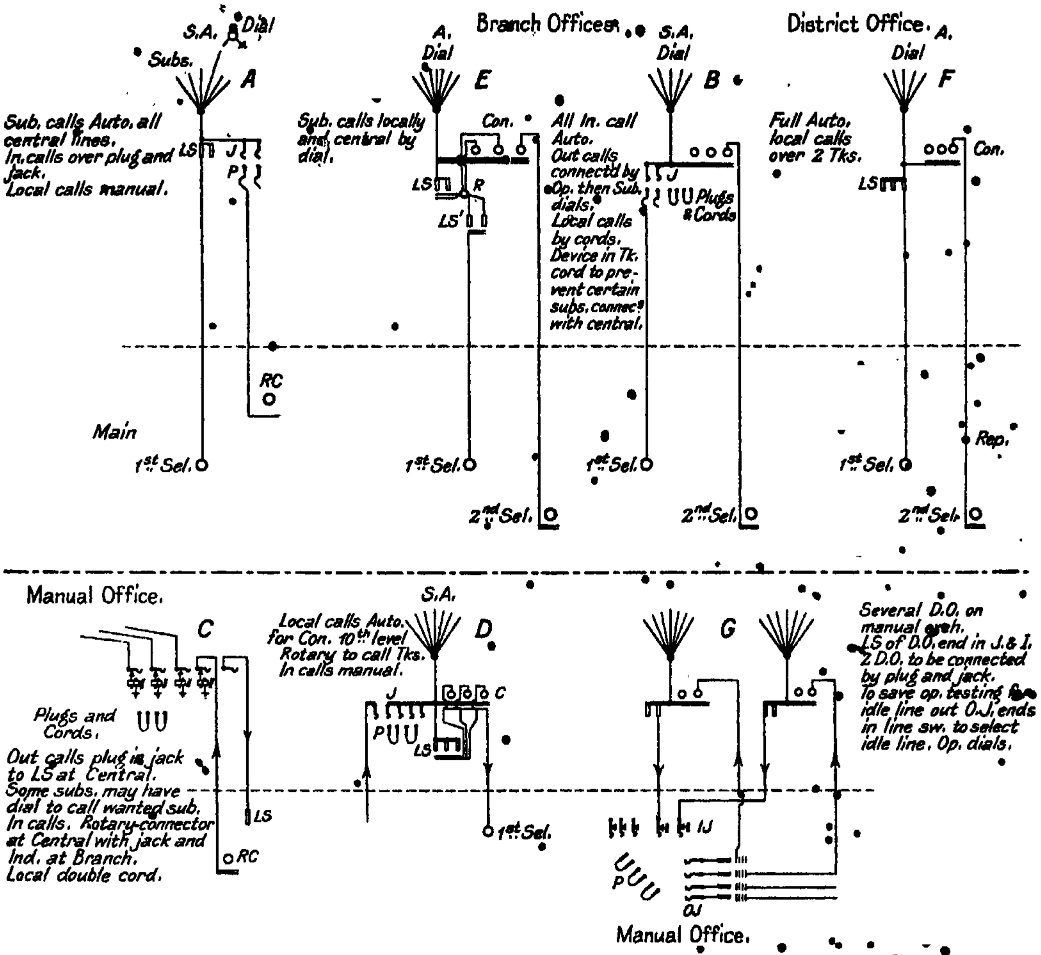

S.A. Dial
Subs.
A
Sub. calls Auto. all central lines. In. calls over plug and jack. Local calls manual.
LS
J
P
RC
Main
1st Sel.
A. Dial
Branch Offices.
E
Sub. calls locally and central by dial.
Con.
LS
R
LS'
1st Sel.
2nd Sel.
All In. call Auto. Out calls connectd by Op. then Sub. dials. Local calls by cords. Device in Tk. cord to prevent certain subs. connect with central.
S.A. Dial
B
J
UU Plugs & Cords
1st Sel.
2nd Sel.
District Office.
A. Dial
F
Full Auto. local calls over 2 Tks.
Con.
LS
Rep.
1st Sel.
2nd Sel.
Manual Office.
C
Plugs and Cords.
UU
Out calls plug in jack to LS at Central. Some subs. may have dial to call wanted sub. In calls. Rotary-connector at Central with jack and Ind. at Branch. Local double cord.
LS
RC
S.A.
Local calls Auto. for Con. 10th level Rotary to call Tks. In calls manual.
D
J
C
PUU
LS
1st Sel.
G
Several D.O. on manual swh. LS of D.O. end in J. & I. 2 D.O. to be connected by plug and jack. To save op. testing for idle line out O.J. ends in line sw. to select idle line. Op. dials.
IJ
PUUU
OJ
Manual Office.

FIG. 50.—BRANCH AND OTHER SMALL OFFICES. TYPICAL ARRANGEMENTS OF CIRCUITS.

are connected to jacks and the banks of connectors. The outgoing trunks end in plugs in the branch office and in the wipers of a selector at the central. Local connections are completed by plug-ended cords. In such an arrangement all calls from the subscribers are signalled to manual operators on lamps, or other indicators, and a local connection is completed by a common battery-cord circuit. If the call is for a central line, the trunk plug complete the connection by dialling the number wanted; alternatively, the operator may dial. A device may be inserted in the trunk to prevent prohibited lines from obtaining connections in the central. The incoming trunks ending on connectors enables any central subscriber to call any party in the branch office.

Such an arrangement is useful for partially converting a manual office to work in with an automatic office, particularly during a transition period.

At C is shown a branch office almost entirely manual, but working in connection with an automatic central. All local subscribers' lines end in jacks and calling signals. The incoming trunks are also similarly ended, and at the central end in banks of rotary connectors. The outgoing trunks also end in jacks, and at the central are connected to the plunger parts of line switches. All connections at the branch office are made by double plug-ended cords. The operator may dial central connections, or certain subscribers' instruments may be fitted with dials which are used after the operator has extended the connection.

At D is shown another arrangement in which the subscribers' lines end in plungers of line switches LS, connector banks, and also in jacks. The line-switch banks are connected to the wiper parts of the local connectors, so that any local number can be called. The tenth level of the connectors are rotary, *i.e.* on that level, the wipers will step round automatically to find an idle line. This tenth level connects with trunks to the central, which end on line switches, or first selectors there. The incoming lines from the central final selectors end in jacks in the branch office, and are connected to local lines by double plug-ended cords.

Automatic Branch Offices.—In full automatic branch offices with considerable local traffic, an objectionable feature was the utilising of an outgoing and an incoming trunk for a local connection. This has now been eliminated, and these connections may now be completed locally without retaining two trunks in use for the connection. Where the number of local connections is few, the simpler arrangement is still to use two trunks. At E is shown a branch office in which the local connections do not use trunks. The subscribers' lines are connected to the plunger parts of line switches LS, and to the banks of connectors C. The banks of LS are wired to discriminating switches R, from which branches lead to the wipers of the local connectors, and other branches to secondary-line switches LS'. When a receiver is lifted, the line switch LS operates to extend the calling line to the discriminating switch R. According to the value of the first digit called the line will be extended to the central or to the branch office. A local call or a central call is thus completed automatically. The incoming trunks at the central are multipled over banks of the last selectors, and at the branch-office end on the wiper parts of connectors.

At F is shown an arrangement which usually goes by the name of *district office*. It simply consists of a detached part of a central office equipment located at some distance therefrom. The subscribers' lines are connected to line switches LS for outgoing calls, and to the banks of connectors for incoming calls. The LS extends the local lines to first selectors at the central, which in turn command the whole exchange. The incoming trunks are multipled over the banks of the last selectors at the central, which may be rotary in groups when the number of trunks are few, or they may be on rotary connectors. At the branch office they end on the wiper parts of connectors. The whole operating is therefore automatic, but two trunks, an incoming one and an outgoing one, are involved in each local connection. As, however, these district offices are mostly feeders to the central, there are only a small percentage of local calls, and frequently these are in the evening and of the nature of social calls. The trunks can then be spared, and the equipment is kept in its simplest form.

Current feeding or charging is usually automatic, and fault-indicating devices at the central show when local troubles occur, so that these are rarely visited by the technical staff.

These offices are frequently used as feeders to manual offices, and this is indicated at G. Two district offices are shown. The outgoing lines end directly in jacks and calling signals. The incoming lines end at the manual office in the banks of line switches, the plungers of which are connected to jacks. This is to render it unnecessary for the manual operator to test for an idle trunk to a district office. On the insertion of the calling plug, an idle line is automatically selected. In response to a calling signal, the operator will insert an answering plug in the answering jack, and, as required, insert the calling plug into a jack of a trunk to the same district office, to another district office, or into a jack of a line in the manual exchange.

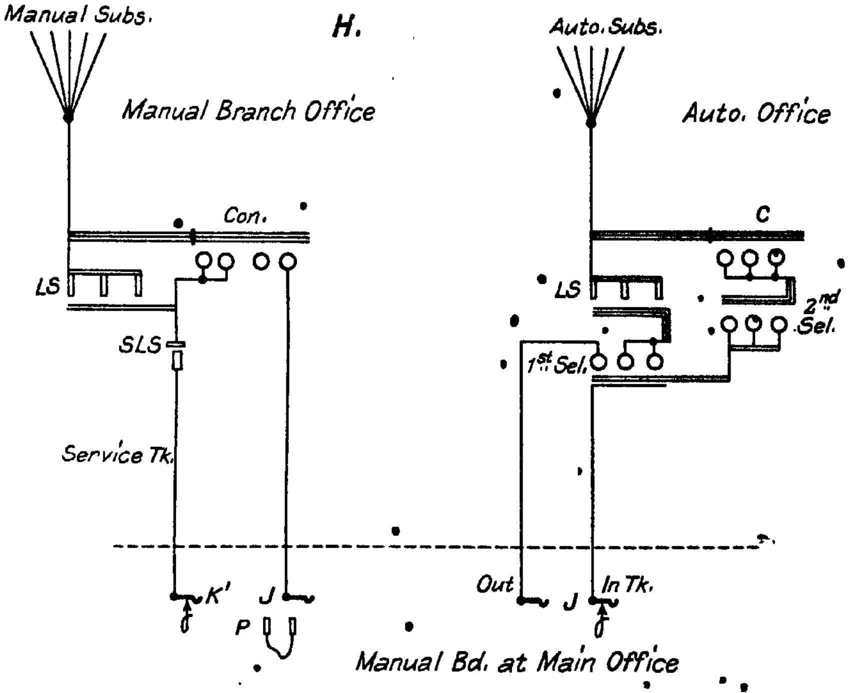


FIG. 51.—TYPICAL MANUAL BRANCH OFFICE WORKING IN CONNECTION WITH A MANUAL CENTRAL AND AN AUTOMATIC OFFICE.

Other arrangements can readily be designed to meet particular requirements.

Manual Branch Offices worked without Operators.—Such an arrangement is sometimes useful. The work may not be sufficient to render an operator's services economical, or it may be expedient to close down an office for, say, two-thirds of the twenty-four hours.

Such an arrangement is shown in Fig. 51. The local lines are equipped with the ordinary manual instruments. The local lines terminate in line switches LS, and the banks of connectors in the branch office. The line-switch multiple is extended to the wiper parts of local connectors and, in parallel, with second line-switches SLS. The multiple of these

SLS are connected to service trunks to the main office, where they end in keys and lamps, the former, when operated, connecting the service trunk to the operator's telephone circuit. For local calls the lifting of the receiver glows a lamp at the central, when the operator depresses the key to connect up her telephone. She then dials back over the service trunk the local number wanted, which actuates the connector, picked up by the caller, to connect with the line wanted. The second line switch is then released and the service line made available for other calls.

When a call is made from a local line for a main office number, the operator takes the numbers of the calling and called lines, calls the number wanted, then, with the other plug of the pair of cords, connects with a trunk leading to connectors in the local office. She then calls the party who originated the call by a calling device in the cord.

The main office may have associated with it also one or more automatic offices to which the closed branch office can have connection. This is also shown at H. Local and incoming calls to the branch office are shown for four digits. Calls to the manual main office are obtained by calling one digit.

The local lines end in line switches and the banks of connectors. The LS banks are multipled to first selectors, the banks of which connect with trunks to the main office, where they end in jacks and calling signals. For outgoing calls from the central, plugs are inserted in jacks the lines of which end in first selectors, which extend the line to second selectors, then to connectors, in the well-known manner.

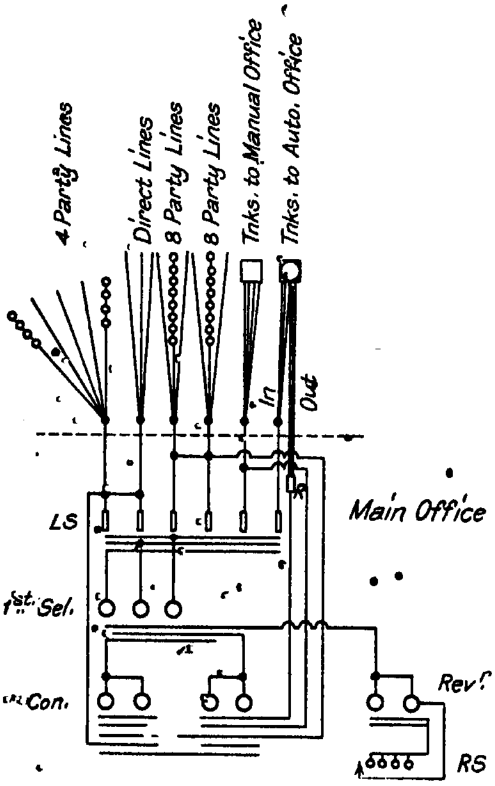


Fig. 52.—Typical "Community" Exchange.

Small Central Offices.—At Fig. 52 is shown diagrammatically a central office suitable for a small town in a populous but scattered area, requiring various kinds of service to meet the public needs. There will be direct lines from the business and better-class residences, and 4- and 8-party lines from smaller properties, or from further afield when a direct line would not be economical. Further away still may be small manual and automatic offices having incoming and outgoing trunks to the central. All the incoming lines connect on line switches first, the multiples of these connecting with first selectors. The selector multiples connect with two groups of connectors from different levels, and another level connects with vertical and rotary switches *Rev.*, which are used for revertive calls, *i.e.* calls to stations on the same party line as the caller. A rotary ringing switch RS works in connection with these.

The connector multiple of the tenth level connects with automatic offices, through which the caller dials extra digits to call a party therein. The ninth or other level may be reserved for trunks to manual offices. Eight-party lines utilise the same level of both groups of connectors for selective ringing (this is really the reason for dividing into two groups). One or both divided groups suffice for 4-party lines. The frequency used on party lines is 16⅔, 33, 50, 66. On 8-party lines two bells of each frequency are fitted, one of each receiving a code ring of single strokes, and the others double strokes.

The other levels are used for direct lines, and the seventh level of the left-hand group are shown multipled to the subscribers' direct lines and 4-party lines. The eighth level is multipled to 8-party lines. The ninth level to manual office outgoing trunks, and the tenth level to automatic office outgoing trunks, these passing through repeaters R.

Such a system is known as a *community exchange* in the United States, and further reference is made to these later on.

Section 21

BRANCH SWITCHBOARDS IN SUBSCRIBERS' OFFICES

In connection with automatic branch switchboards in subscribers' offices in this country, the Post Office has specified (as quoted below) what traffic facilities must be provided. These, practically, limit the use of automatic switching to local calls only, all calls to and from the main office being completed by an attendant.

As something like 90 per cent. of these switchboards are equipped for fifteen lines and under, there will be no inducement to prefer an automatic installation, because the attendant, who must be provided for the calls over the public exchange, might just as well occupy her time by completing the local calls.

In many cases no regular attendant will be provided, and the duties of supervising the connections and freeing the junctions for further calls will devolve on the office boy, or other irresponsible person who, when available and so disposed, will perform the necessary acts. The subscriber must, therefore, be content with an inferior service or provide a regular attendant; but, whilst *he* may be content with the former, it must at the same time be realised that the whole telephone service of the area is depreciated, because every call that is not cleared promptly not only holds the local junction occupied unnecessarily, but every junction and subscriber's line involved in the connection suffers.

To provide for supervision on outgoing and incoming connections, repeaters, or condensers and impedance coils, have to be introduced, and the transmission must necessarily suffer, and this will be particularly felt when two extension lines are talking together over the main system. If the transmission efficiency of two direct lines talking together in the same office is taken as 1, then the efficiency of two branch lines talking through a main office is equal to 3.

The automatic service described is more restricted than that of any other known Administration. Almost invariably outgoing automatic service is given, and incoming service is fairly common. In the latter case particularly, but mostly on the larger installations, the subscriber often prefers that the incoming calls should be sifted and distributed by the local attendant. In the small installations it should be in the interests of the subscribers and of the Administration to eliminate the local operations entirely—from the service point of view.

AUTOMATIC P.B.X.'S—TRAFFIC FACILITIES

Exchange Calls.—These calls will be dealt with by the P.B.X. telephonist, who will complete :—

(*a*) An outgoing call—by plugging into the exchange jack.

(*b*) An incoming call—by plugging into the jack directly associated with the required extension. This action shall engage the associated multiple on the automatic equipment.

The circuit arrangements shall be such that on calls made to the manual board :—

(*c*) (i.) The calling extension shall be able to release the connection before the P.B.X. telephonist answers.

(ii.) The insertion of the answering plug shall place the calling extension under the control of the P.B.X. telephonist and prevent the connection being released until the plug is withdrawn from the answering jack.

(iii.) The manual telephonist can plug into the multiple jack of an engaged line without breaking down the connection on the automatic equipment for the purpose of offering an exchange or other call.

(iv.) Through signalling between the extension telephone and the public exchange is not required. The P.B.X. telephonist will control the connection and obtain switchhook supervision from the extension.

Local Calls.—Local calls shall be completed automatically. The engagement of an extension line on the automatic switching equipment shall engage the associated multiple jack on the manual board.

Back Release.—" Back-release " conditions shall be provided on local calls only.

Dialling Signals.—The circuit arrangements shall be such that, when the calling subscriber's line engages a connecting circuit, an uninterrupted signal shall be given to indicate that dialling may be commenced. This signal shall continue until the first digit has been dialled, and shall not thereafter be connected to the circuit until the connection has been released, and the connecting circuit taken into use for another call.

Busy Back Tone.—The circuit arrangements shall be such that, whenever a connection in progress finds (*a*) all outlets, or (*b*) the called subscriber, to be engaged, a busy back signal shall be given to the calling subscriber. In systems in which continuous hunting facilities are afforded, the busy signal should not be given under condition (*a*) unless this condition continues for approximately 30 seconds on any group of outlets.

Audible Ringing Signal.—The circuit arrangements shall be such that :—

(*a*) On all local calls to automatic extensions, where the connection has been set up and the ringing current applied, a ringing signal shall be transmitted to the calling subscriber. This signal to continue until the subscriber answers.

(*b*) On all calls dialled direct to the manual board a ringing signal shall be transmitted to the calling subscriber from the time the connection is set up until the telephonist replies to the calling signal.

Dead-Level and Dead-Number Calls.—The circuit arrangements shall be such that when a " Dead Level," " Dead Number," or a faulty line plugged out on the main frame is dialled, the calling subscriber shall be connected to a continuous tone signal which will be known as the " Number Unobtainable Tone."

Night Extension Facilities.—Arrangements shall be made for extending any of the exchange lines to any extension line during night or any other desired periods when an operator is not at the manual board. The arrangement shall be such that the calling signal and supervisory signal at the public exchange are controlled directly by the extension subscribers' telephone loop, and that it can be effected by direct connection between the exchange line jack and the subscribers' jack on the manual board by means of a cord circuit which will permit the cord circuit being used in the ordinary manner, or as a straight through-connection cord circuit.

Arrangement shall be made to ensure that when any extension line is so connected to the public exchange, this line shall test busy on the automatic switch.

Extension of Alarm-Signal Circuits to Manual Board.—Alarm signals shall be provided for the effective supervision of the working conditions of the automatic equipment.

The alarm-signal circuits shall be extended to the P.B.X. manual board, where they shall terminate on suitably-designated lamps, located at the top of the jack field.

Section 22

AUTOMATIC DISTRICT OFFICES IN CONNECTION WITH MANUAL SYSTEMS

In existing manual systems modified automatic district stations may be used with advantage as valuable adjuncts, either to avoid expensive underground cable work, the provision of new manual plant, or expensive additions to existing plant of limited capacity. The instruments on such an automatic equipment would be of any of the well-known patterns without any automatic feature whatever. At the district station they would be connected to line switches, such as have already been described for outgoing calls. At the manual exchanges these junction lines would end on the usual line and cut-off relay, answering jack, and calling lamp, or on a single-cord equipment, like manual incoming junctions. On the removal of the receiver to call, the line switch would connect with a disengaged

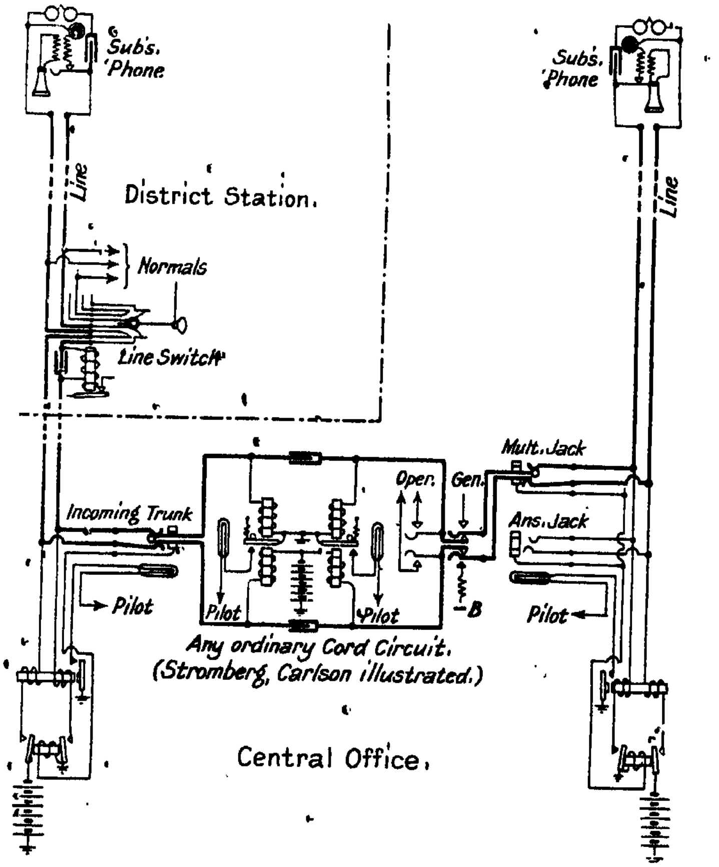


FIG. 53.—Automatic District Station Subscriber connected through to a Manual Office Subscriber.

junction instantly, and the line lamp would glow, and the operator would complete the connection in the usual way, the service being absolutely similar to a connection in a purely manual exchange. Fig. 53 shows such an arrangement on the A. T. M. Co. (A. E. Co.) system. For outgoing calls from the manual exchange an operator would have, in addition to the ordinary double-cord equipment, a switch to connect up a dial-calling device, by which, after making the connection, she would call the number required in a manner similar to a subscriber calling on a full automatic system. All the lines in the district station are multipled on to connector banks to allow of them being called. Fig. 54 shows such an arrangement. The above method supposes a complete multiple of the manual exchange to be available. Another method is to multiple the outgoing junctions over the manual board and on to a controlling operator's position, which may be away from the multiple. This operator would have a key in each junction to switch in the dial-calling device and a lamp to indicate what lines were engaged. A manual operator receiving a call for a district station number would momentarily connect her telephone to a call or order wire, and inform

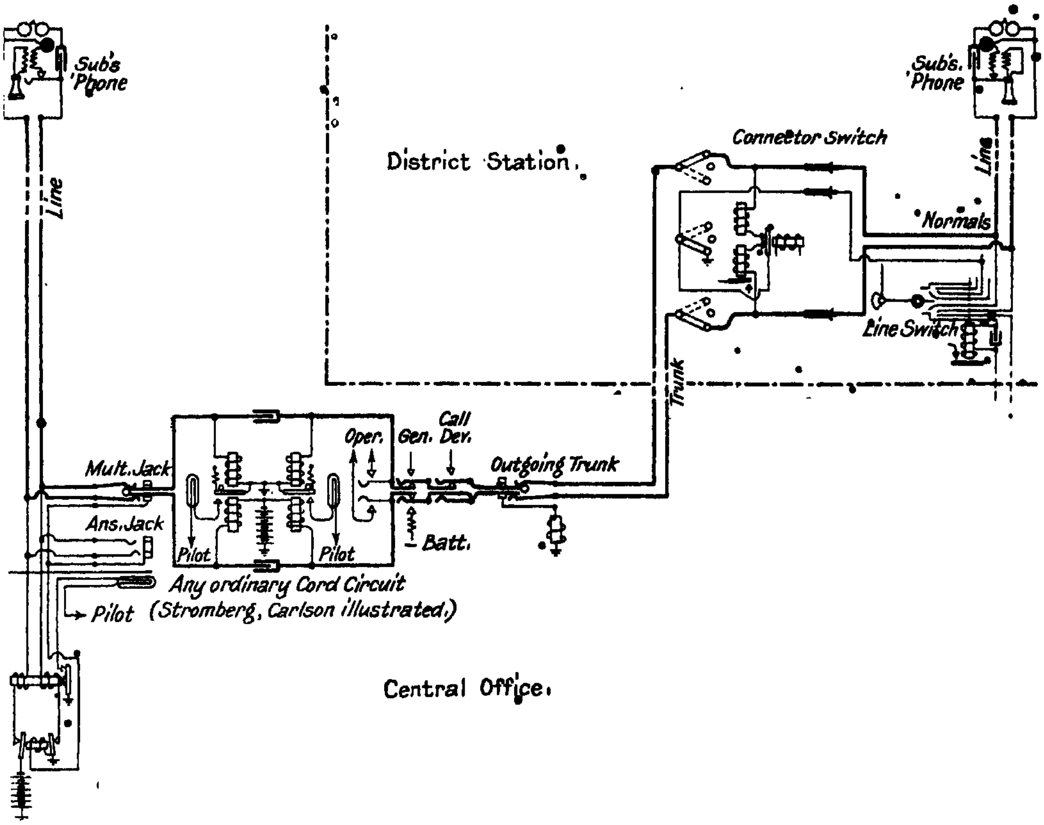


FIG. 54.—MANUAL OFFICE SUBSCRIBER THROUGH TO AN AUTOMATIC DISTRICT SUBSCRIBER. DIRECT WORKING.

the control operator the number wanted. That operator would allot a junction, to which the manual operator would make connection. The controlling operator would call by the dial and ring the subscriber wanted, and the manual operator would supervise the connection by the cord lamps in the usual way. The withdrawal of the plugs after the clearing signals were obtained will give the signal "junction disengaged" to the controlling operator and automatically restore all apparatus at the district exchange to normal. Fig. 55 shows such an arrangement. It will be readily understood that two district station subscribers can be connected together by the circuits already described by the use of two junctions, one incoming and one outgoing.

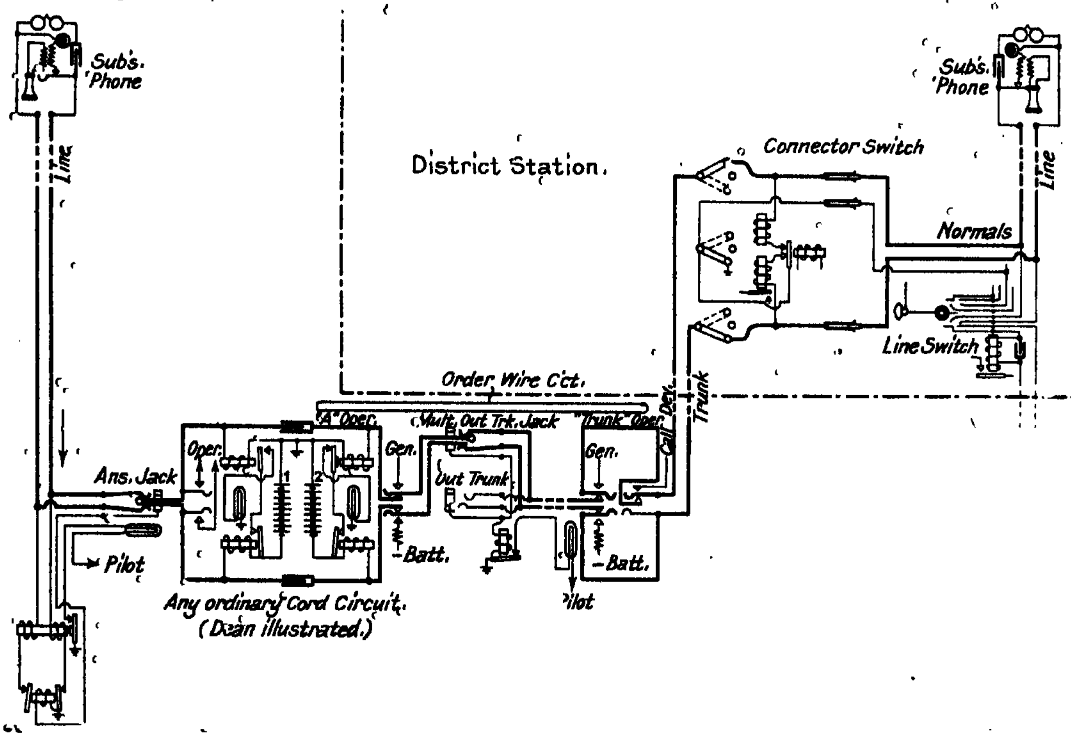


Fig. 55.—A Manual Office Subscriber connected to a District Station Subscriber. A to B Operator Working.

Section 23

A. E. CO.'S MAIN AND DISTRICT OFFICE ALARM APPARATUS

Fig. 56 shows an arrangement of trunks between two district offices and a main office. Fig. 56ᴀ shows a method of supervising a district office from a test desk at the main office.

1. If there is a fault on an individual circuit R' energises.
2. R2 energises (the 25-ohm relay does not energise in series with the 2000-ohm coil).

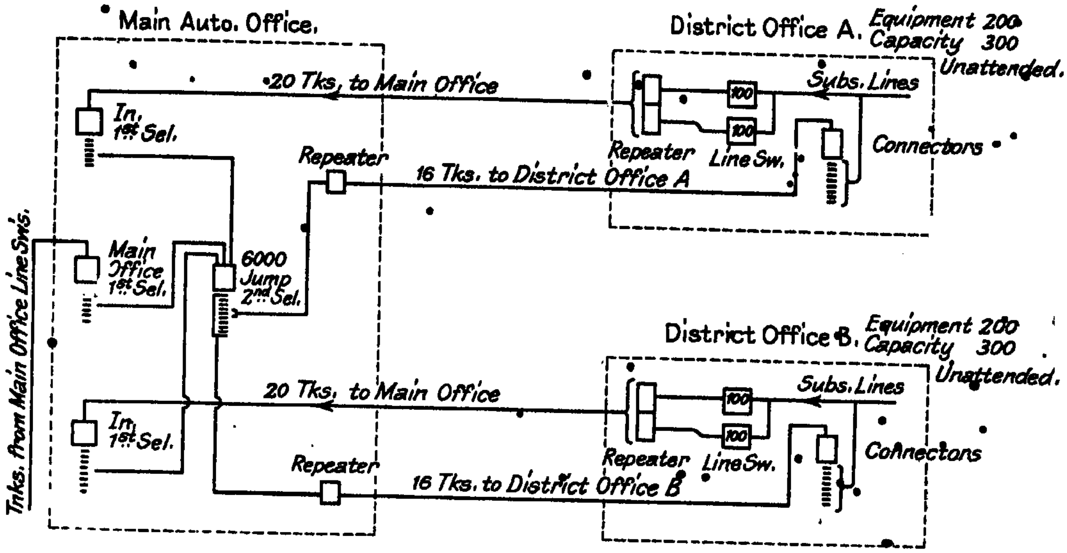


Fig. 56.—District Offices—Unattended (A. T. M. Co.).

3. White lamp L3 glows, and the common alarm relay R3 energises.
4. R3 holding circuit.
5. Alarm circuit.
6. Fault on a common circuit R6 energises.
7. R7 and R2 energise.
8. Red lamp L8 glows (circuit of L3 may be opened). R3 energises, locks, and alarm given.

The red lamp indicates that urgent attention is required.

Dialling a particular number will find out which circuit requires attention. If generator fault, a duplicate machine may be switched into circuit by dialling.

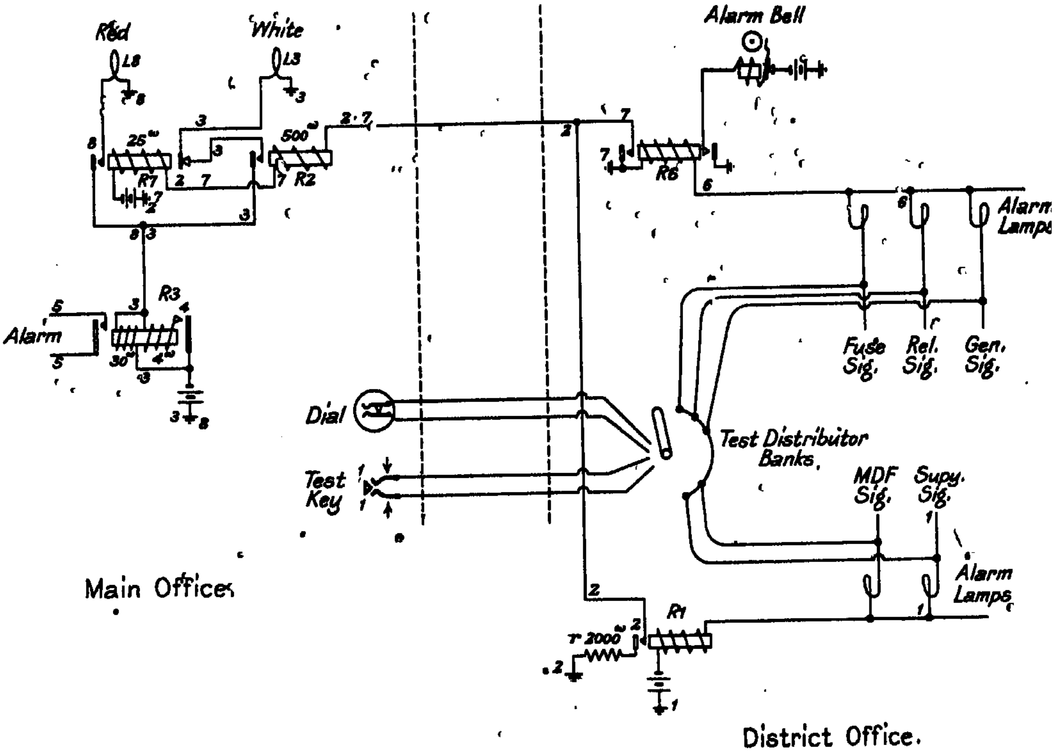


FIG. 56A.—MAIN AND DISTRICT OFFICE ALARM APPARATUS AND METHOD OF SUPERVISING FROM TESTER'S DESK AT MAIN OFFICE.

Section 24

BRANCH OFFICES—FULL AND RESTRICTED SERVICE

Branch offices in a multi-office system may be of considerable size and contain selectors as well as connectors.

In Fig. 57 is shown, in outline, part of an A. T. M. Co. arrangement in which the branch office has selectors, repeaters, and connectors. The main office may have first and second selectors and connectors.

The circuit also shows a method of preventing certain lines in the branch office having connection over the trunks to the main office.

Such restricted service is frequently necessary in connection with what are sometimes known as P.A.X. or private installations in works, warehouses, and the like. In such it is not advisable to allow all the lines to have exchange facilities, and means have therefore to be found to prevent them enjoying facilities they are not entitled to.

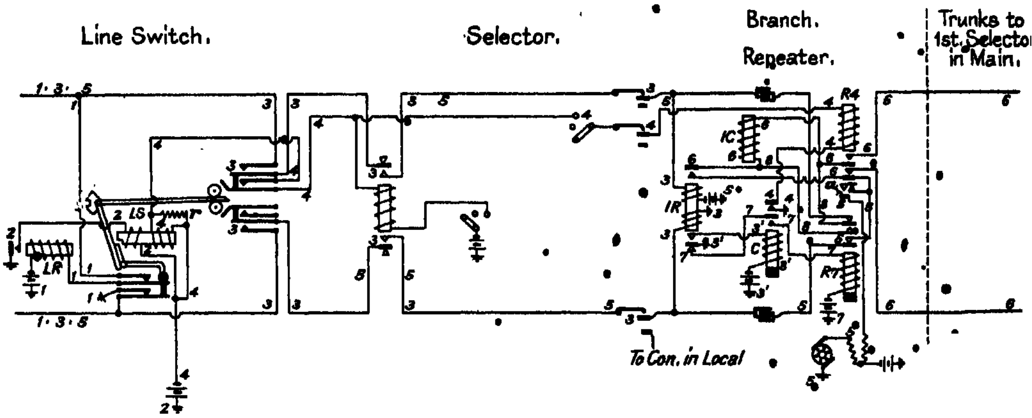


FIG. 57.—BRANCH OFFICE WITH SELECTOR AND REPEATER. FULL AND RESTRICTED SERVICE.

The subscriber's instrument, line switch, and selector are of a well-known pattern. The line switch holding coil is now, however, shunted when the line with which it is associated is to have full service. Lines which are to have local intercommunication only are not fitted with this shunt.

The circuits are numbered in the order of operation and are as follows :—

1. When the receiver is lifted the line relay LR energises.

2. The line switch LS energises to force the plunger into the bank contacts and the master switch rotates the plungers until they are opposite the next idle trunk.

3. *It is assumed that the first digit has been called* and the line extended to the repeater. Relay IR energises.

3′. Relay C energises when relay IR first energises.

4. Holding circuit. Relay R4 is marginal. If the shunt *r* is not across the LS winding, then it energises only sufficiently to close contact *a*. When the shunt *r* is added relay R4 energises fully.

5. When R4 is partially energised, a busy signal is given the calling subscriber, informing him that connection cannot be made with the main office.

6. When R4 is fully energised, the line is extended to the first selector in the central office. Relay IR there energises.

Second digit impulses.—Relay IR de-energises according to impulses. Circuit 6 opened. First selector at central extends line to second selector.

7. Relay R7 energised for duration of impulses. Opens circuit 5 towards the calling subscriber.

8. Impedance coil IC short-circuited so as not to interfere with impulses.

Third digit impulses.—IR″ of second selector operated through the repeater to extend the line to the connector.

Fourth and fifth digit impulses actuate the connector in known manner.

The local office is operated by three digits. The selector connects with the local office or central according to the level called.

Section 25.

BRANCH OFFICE FOR DIRECT AND PARTY LINES

In this A. T. M. Co. arrangement the connector by the aid of an auxiliary switch calls into a group of 300 lines. Each connector at a branch office has a one co-ordinate switch associated with it, which is actuated by the first digit impulses. The connector has three sets of wipers so as to have access to three groups, of 100 lines each, one set of wipers being connected up at a time by the auxiliary switch.

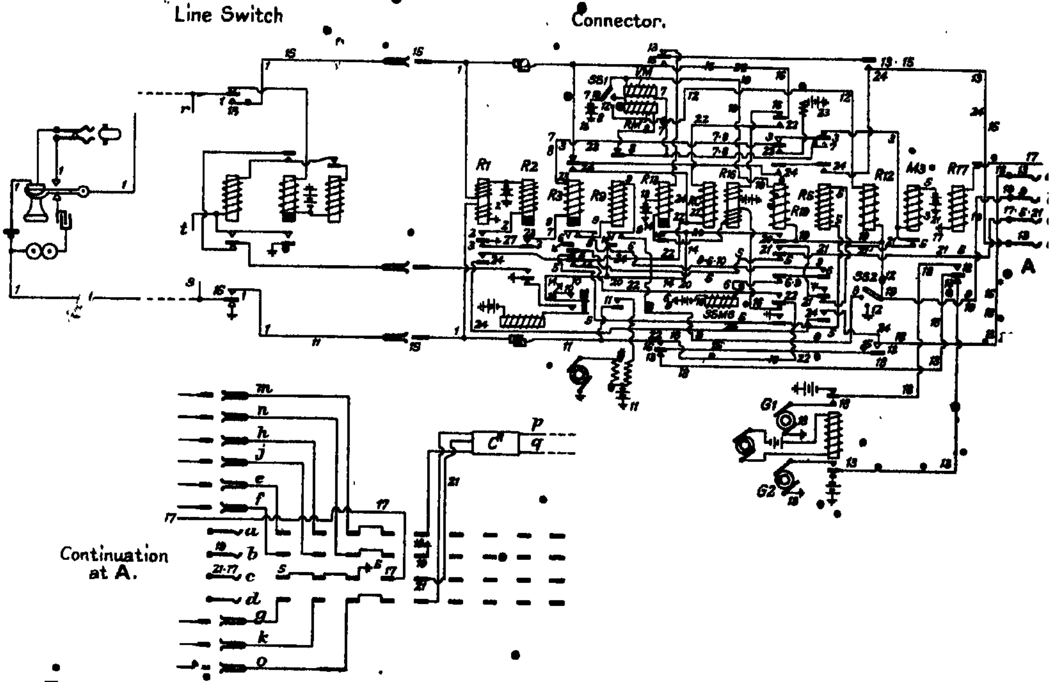


FIG. 58.—BRANCH OFFICE WITH DIRECT AND PARTY-LINE CONNECTOR. 300 LINES CAPACITY BY AUXILIARY SWITCH.

If the first digit is 1, the auxiliary switch *a*, *b*, *c*, *d* (Fig. 58) selects the first set of wipers *e*, *f*, *g*.

If the first digit is 2, it selects the second set of wipers *h*, *j*, *k*

If the first digit is either 3 or 4, the switch *a*, *b*, *c*, *d* selects the third set of wipers *m*, *n*, *o*. These have access to a group of 100 2-party lines. One or other of the ringing generators G′ or G2 is brought into use according to the digit dialled.

If the first digit is 5, the switch *a*, *b*, *c*, *d* moves to its fifth, or to a subsequent set of terminals, to make direct connection to an idle trunk line, such as *p*, *q*, leading to the main office. The second, and further, sets of impulses are repeated to a selector at the main office, without actuating the connector at the local office.

Local connections to direct or individual lines.

A calling line is extended in a manner previously described.

1. Impulse relay R′ energises.

2. Slow-to-de-energise relay R2 energises.

3. *On the first impulse* the slow-to-de-energise relay R3 energises for the duration of the impulses. M3 energises to step the auxiliary switch to either the first or second set of connector wipers.

5. After the impulses R3 de-energises. R5 (high resistance) energises in series with M3, which does not energise.

6. *The second set of impulses* are repeated through R3, which now controls the side-switch magnet SSM6.

7. R3 energises for the duration of the impulses, and the vertical magnet VM of the connector steps-up the shaft and wipers to a corresponding level.

After the impulses R3 de-energises and the side switches move to their second position.

8. *The third set of impulses* pass to the rotary magnet RM. R3 energises for the duration of the impulses and closes circuit 6 for SSM6. RM rotates the wipers to a corresponding terminal.

After the impulses R3 de-energises and, if the called line is idle, the side switches move to the third position.

9. If the called line is busy R9 energises, in series with SSM6, over wipers *b* and *f* (or *j*).

10. Holding circuit of R9 and SSM6.

11. Busy tone to caller.

12. If the line is idle, R12 energises and connects the line through for ringing.

13. Ringing circuit to called subscriber. R13 does not energise until the subscriber answers.

14. R13 locking circuit. Circuit 13 opened to cut off ringing.

15. Lines connected for talking.

16. Back-bridge relay R16 (battery feed) connected to line.

Local connection to party lines.—The operation, generally, is the same as just described, but the first digit impulses move the switch *a*, *b*, *c*, *d* to the third or fourth set of terminals, both of which are connected to the third set of connector wipers.

17. If the switch *a*, *b*, *c*, *d* is moved to its fourth set of terminals, R17 is energised in series with R5.

18. Ringing generator G′ is connected to line. G′ or G2 is used accordingly as the digit is 3 or 4.

Outgoing calls to main office.—The first digit called is 5, which moves the switch *a*, *b*, *c*, *d* to its fifth set of terminals.

19. R19 energises over the side switches in position 1, and over the *b* wiper.

20. R19 holding circuit. R19 prepares a hunting circuit for the switch *a*, *b*, *c*, *d*.

21. If the first main office trunk *p*, *q* is busy, M3 is energised and advances *a*, *b*, *c*, *d* until an idle trunk is found. While the switch is passing over busy trunks R5 is short-circuited by the earthed test wiper *c*; but when an idle trunk is reached, R5 energises and opens circuit 3, so that M3 de-energises.

22. The outgoing trunk is bridged by an inductance RC22. Subsequent sets of impulses are repeated over the trunk by R′.

23. R3 energises for the duration of the impulses.

24. Impulses over trunk RC22 short-circuited.

Main office trunks may have access for incoming calls over line switches C′ to local connectors.

Section 26

CONNECTIONS BETWEEN LOCAL LINES IN A BRANCH EXCHANGE WITHOUT UTILISING TRUNKS THROUGH THE CENTRAL

In large exchange-systems, consisting of one or more large central offices and smaller offices, it has been the usual custom for connections between two local lines in one of the small offices to complete the connection through a central office, thus using an incoming and an outgoing junction between the two offices.

Apparatus and circuits have been devised to make the connection entirely locally and to reserve the junction lines solely for inter-office connections. The arrangements are still somewhat expensive and utilise the junctions momentarily whilst initiating and building up the connection to some extent.

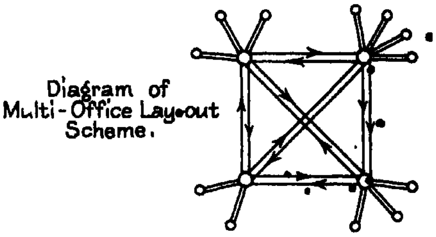


Fig. 59.—Multi-Office Working.

As shown in Fig. 59, a multi-office system may consist of four large offices, shown at the corners of a rectangle, connected together by incoming and outgoing junctions, shown forming the sides of the rectangle and also by diagonal lines. Radiating from each large office may be a number of smaller offices connecting only with one large office by junctions, but having service through that office with the whole system.

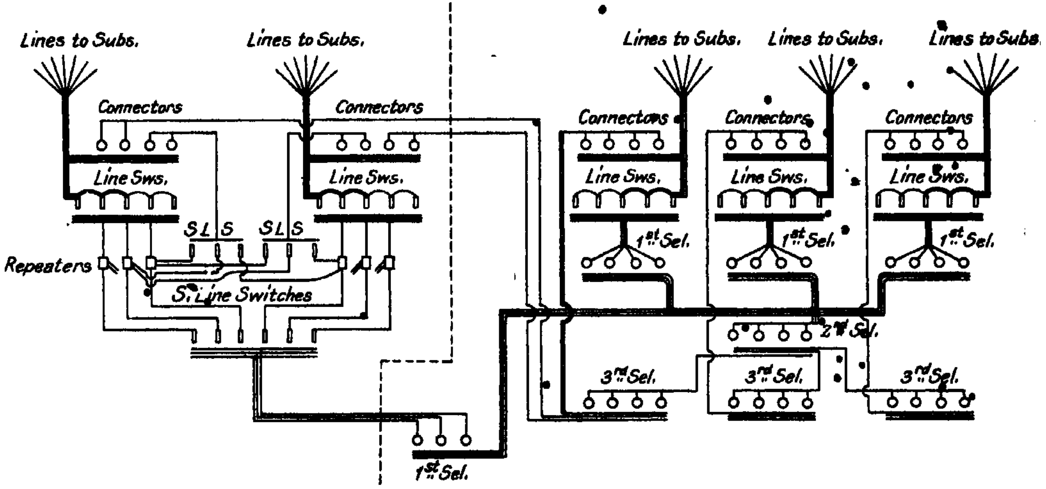


Fig. 60.—Satellite Office.

Fig. 61.—Main Office.

System with Switching Repeaters (A. T. M. Co.).

It is assumed that five-figure calling is required to complete a connection between any two lines. The arrangement of apparatus and junctions is shown diagrammatically in Figs. 60 and 61 for a satellite and a main office, with facilities for local inter-connection.

The satellite is shown at Fig. 60, and the main or central at Fig. 61. The subscribers' lines in the former are shown connected to line switches and to bank contacts of connectors. The banks of the line switches are multipled to repeaters. These repeaters do repeat the impulses, but are really discriminating or determining means to extend the calling line to a junction to the central, or complete the connection locally according to the value of one or more of the prefixing digits. It will be noticed that these repeaters have lines to secondary line switches, the banks of which connect to the wiper parts of connectors on which the local subscribers' lines are multipled. The repeaters have also lines to secondary line switches, the banks of which are multipled to junctions to the central office, where they end on first selectors. The banks of these first selectors are multipled to the wiper parts of second selectors, which in turn are multipled to third selectors whose banks connect with connectors to reach the subscribers' lines of the central.

The main exchange is equipped in a somewhat similar manner, but without discriminating means. The line switches extend the calling line automatically to first selectors, the first digit extends the line to second selectors, the second digit extends the line to third selectors, the third digit extends the line to the connectors, which in response to two digits connect with the chosen line. The value of the third digit determines whether the connection is to be completed in the main or in the branch office.

The circuit according to Fig. 62 assumes that the branch office has under 1000 lines, and that the numbers allotted to it are from 11,000 upwards. The numbers in the main office may be 22,000 upwards.

In Fig. 62 the subscribers' instrument and line switches are not shown and may be read from any other circuit. The line switch bank springs are shown on the left.

The circuits are numbered in the order of operation and are as follows :—

Calling a subscriber on the main office.

1. When the receiver is lifted, the line is extended by the line switch to the discriminating switch. Relay 1R energises.

2. Guarding relay G energises.

3. Holding circuit of the line switch.

4. Relay R4 energises.

5. Secondary line switch (not shown) energises, to extend the calling line to a first selector in the main office.

6. Loop circuit in which relay IR′ of first selector energises.

Relay R4 does not energise, as the current in the two windings oppose each other. R6 energises.

First digit impulses.—Relay IR responds intermittently.

7. Vertical magnet VM energises to lift the shaft, but this is functionless, as it can complete no circuit on this level. Circuit 6 is opened to repeat the impulses to the main office selector.

8. Relay R8 (slow to de-energise) is energised for the duration of the impulses. Opens one side of the talking circuit and short-circuits the upper windings of relays R4 and R6 to lower the resistance to impulse currents to relay IR′ of selector in main.

9. Escapement magnet EM energises. After impulses R8 and EM de-energise, the latter moves the side switches to the second position.

At the main exchange, at the same time, the side switches are moved to the second position ; then the rotary magnet, acting automatically, steps the wipers to an idle trunk.

after which the side switches are moved to the third position, and the line is extended to a second selector.

Second digit impulses.—The impulses are repeated as before, and the vertical and rotary magnets at the main office cause the line to be extended to a third selector. The rotary magnet of this switch, which is now acting as a repeater, is also actuated but is again functionless.

The magnet EM acts as before to move the side switches to the third position.

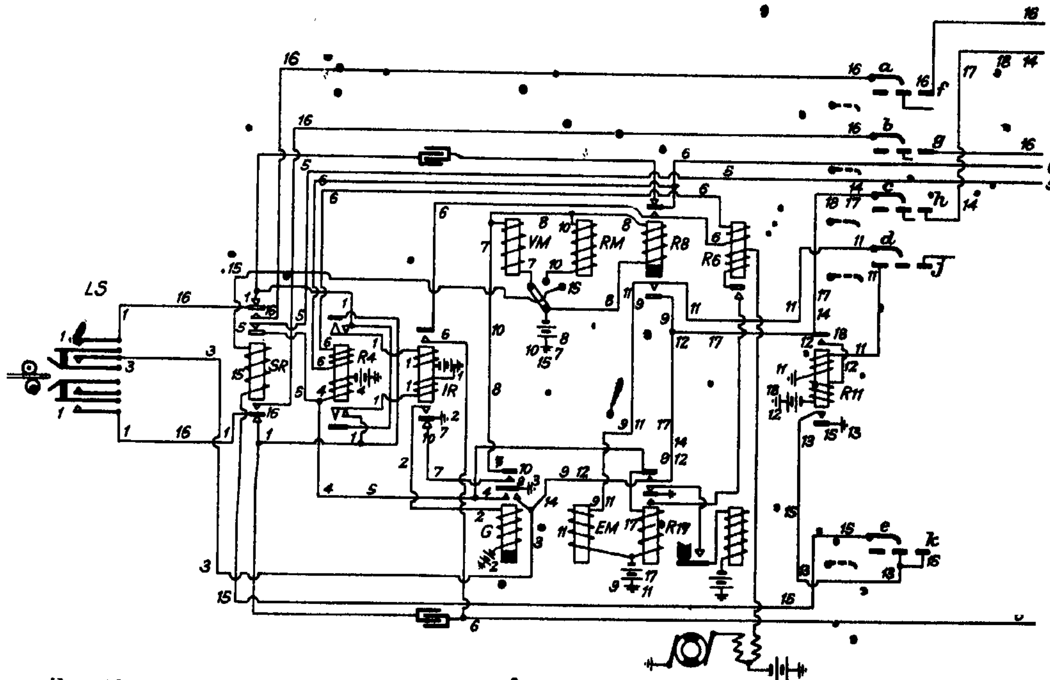


FIG. 62.—LOCAL CONNECTIONS IN A BRANCH OFFICE WITHOUT UTILISING TRUNKS THROUGH THE CENTRAL OFFICE (A. T. M. Co.).

Relay SR is connected to battery by the side switches, but is functionless at present.

Third digit impulses.—The repeater acts as before on the third selector to extend the line to a connector in the main office.

Fourth and fifth digit impulses.—The connector extends the caller to the called subscriber in the main office.

To Complete a Local Connection.—Number to be called, 11,220. When a receiver is lifted to call, the line is extended to the selector in the main office as before (see circuits 1 to 5).

7. *First digit impulses.*—IR de-energises intermittently. The vertical magnet VM energises to lift the wipers to a local working level. Side switches pass to second position. First selector in central extends line to a second selector.

10. *Second digit impulses.*—Rotary magnet RM energises and steps wipers round to first terminal.

11. Circuit, through wiper *d*, relay R11, and magnet EM energise. EM cannot de-energise after the impulses to move the side switches to third position, but R11 energises.

12. Relay R11 locking circuit.

13. Engaging circuit (no circuit over wiper *e*, as the side switch is not in the third position).

Line to central extended to third selector.

Third digit impulses.—Wipers stepped round over two more terminals, when wipers *a* to *e* make contact with terminals *f* to *k*. After the impulses the side switches are moved to the third position.

Line to central extended to connector.

14. Secondary line switch of local office energised to extend calling line to an idle connector, which has access to all subscribers' numbers beginning 112.

15. Relay SR energises.

16. Calling line extended by wipers *a* and *b* to called line. Repeater de-energises and releases line to, and all apparatus in, central office.

17. Holding circuit of relay R17.

18. Holding circuit of relay R11.

The fourth and fifth digits operate the local connector as explained elsewhere.

(In this, and a few other circuits, an older form of switch is referred to, see Sections 9 and 10, Vol. I.)

Section 27

ANOTHER METHOD OF COMPLETING CONNECTIONS LOCALLY WITHOUT USING TRUNKS TO THE CENTRAL OFFICE

The equipment at the branch office consists of line switches for the local subscribers' lines which are multipled to connectors and secondary line switches associated with the trunks to the central office. The first and second selectors for extending the incoming trunks from the branch office are located at the central. This arrangement deals with small exchanges, particularly those known as P.B.X. The local number will therefore consist of two digits. These are, however, prefixed by another digit, which represents the number of a level on the first selector at the central, reserved for this particular service, and which is left insulated.

Fig. 63 illustrates the arrangement, the circuits of which are numbered in the order of operation, and are as follows :—

The subscribers' instrument and line switch are not shown. The multipled banks of the line switch are indicated on the left.

1. When the receiver is lifted, the line switch is operated to extend the line to the impulse-relay IR of the connector.
2. The guarding relay G (slow to de-energise) energises.
3. Line switch holding circuit.
4. Secondary line switch SLS is operated to extend the line to a first selector in the central office.
5. Loop to selector in central. Relays R5 and IR′ energise.
6. Locking circuit of LS. Relay R6 energises.
7. Locking circuit of R2 (independent of master switch MS).
8. Locking circuit of relay R6.

Any subscriber in the central office may now be called, relay IR repeating the impulses. Relays R5 and IR′ operate together.

9. When relays R5 and IR de-energise when impulsing, R9 energises and opens the condenser circuit (C, C′) for the duration of impulses.
10. Short-circuit of one winding of R5 to reduce resistance.

The circuit 9 is alternately kept closed by IR and R5.

For a local connection, SLS must first be energised.

The first digit will raise the wipers to the dead level of the first selector in the central, and the wipers attempt to rotate. The side switches are then in the third position. No circuit is completed and R5 de-energises, circuit 6 is opened and SLS de-energises.

11. Relay R11 (slow) energises. SLS magnet does not get sufficient current to energise.

Second digit impulses.—IR intermittently de-energises.

12. Relay PMR energises for duration of impulses and vertical magnet VM energises and lifts shaft. PMR de-energising, releases side switches.
13. Magnet PM was also energised for duration of impulses and now, de-energising, trips side switches to second position.

Third local digit impulses.—Relay IR de-energises intermittently.

14. Rotary magnet RM steps wipers round. PMR and PM energise as before. After impulses PMR and PM step side switches to third position.

15. Relay RR intermittently energised to ring subscriber.
16. Ringing circuit to line.

Called receiver lifted.

17. Microphone current circuit. Relay BBR energised.

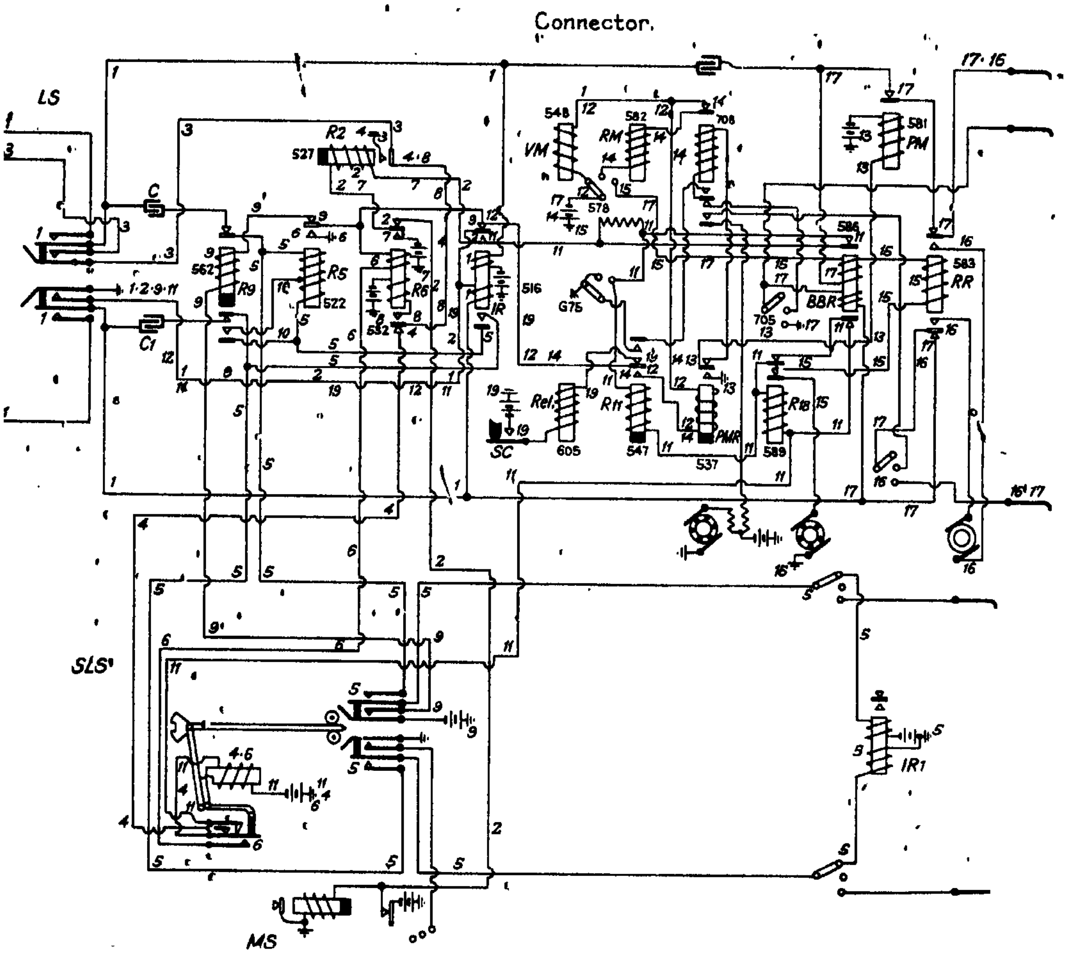


Fig. 63.—Local Connections in a Branch Office without using Main Trunks (A. T. M. Co.).

18. Short-circuit about R18 removed. R18 energises to cut off ringing by opening circuit 15. Circuit 17 also opened to prevent re-ringing should BBR de-energise.

To clear.

Calling subscriber replaces receiver and IR de-energises, then R11 and R2.

19. Release magnet *Rel.* energised. Shaft falls and breaks normal contact SC, and breaks holding circuit, etc.

Section 28

A BRANCH OFFICE CALLING LOCALLY WITHOUT USING CENTRAL TRUNK (WITH ROTARY SWITCH)

A rotary switch is used in combination with a selector at the branch office. In this circuit (Fig. 64) the operation of the rotary line switch is as described on p. 43 of Vol. I.

On lifting the receiver, the calling line is extended to the selector and the rotary switch (C′) selects an idle trunk to the main office. The impulses of the first digit operate the selector shown and also a first selector at the main office. If the level to which the wipers are raised corresponds to a branch office number, the trunk is at once released, and succeeding impulses are received on a selector and connector in the branch office over a local circuit.

If the level first selected corresponds to a main office number the selector shown takes a single rotary step only, and subsequently acts as a repeater to repeat the remaining impulses. Busy tone is given if all the trunks to the main office are busy.

The rotary switch has no normal position, and is arranged to take a step forward when released, so that, should a caller have been connected with a faulty line, he can, by replacing the receiver momentarily, immediately connect with another idle trunk.

The circuits on a local call are numbered as follows :—

1. When the receiver is lifted, the caller is extended to a selector in known manner, and R′ energises.

2. R2 (guard) energises.

3. Polarising circuit of R3 (this is neutralised by circuit 6).

4. R4 energises.

5. R4 locking circuit.

6. R6 energises (line relay of rotary switch).

7. R6 locking circuit.

8. Rotary switch stepping magnet SM8 connected to test wiper. The rotary switch advances until it finds an unearthed test terminal of an idle trunk. R9 has been short-circuited over circuit 8.

9. R9 energises, opens circuit 6, and R6 slowly de-energises.

10. R10, of an idle trunk, energises and engages the trunk over circuit 8 to earth. Earth is cut off the starting wire 6 of the group of rotary switches. Earth remains connected at some other point while a trunk to the main office is idle.

11. The vertical magnet VM11 is energised on the first series of impulses.

12. R12 energises in parallel with VM11.

The windings of R3 and R18, in circuit 6, are short-circuited to give the impulses a clear path to trunk over *a* and *b*.

13. Impulse circuit to trunk referred to above.

After the impulses R12 de-energises, the rotary relay R14 and rotary magnet RM15 co-operate in known manner to rotate the wipers.

14. If the first trunk is busy, R14 energises.

15. RM15 energises, and the wipers take one step. Circuit 14 is opened and R14 de-energises. Circuit 15 is opened and RM15 de-energises, and so on. At the first energisation of RM15, circuit 5 is opened, but R4 remains energised over the wiper *c*. All the terminals are earthed on the levels serving the second selectors of the branch office.

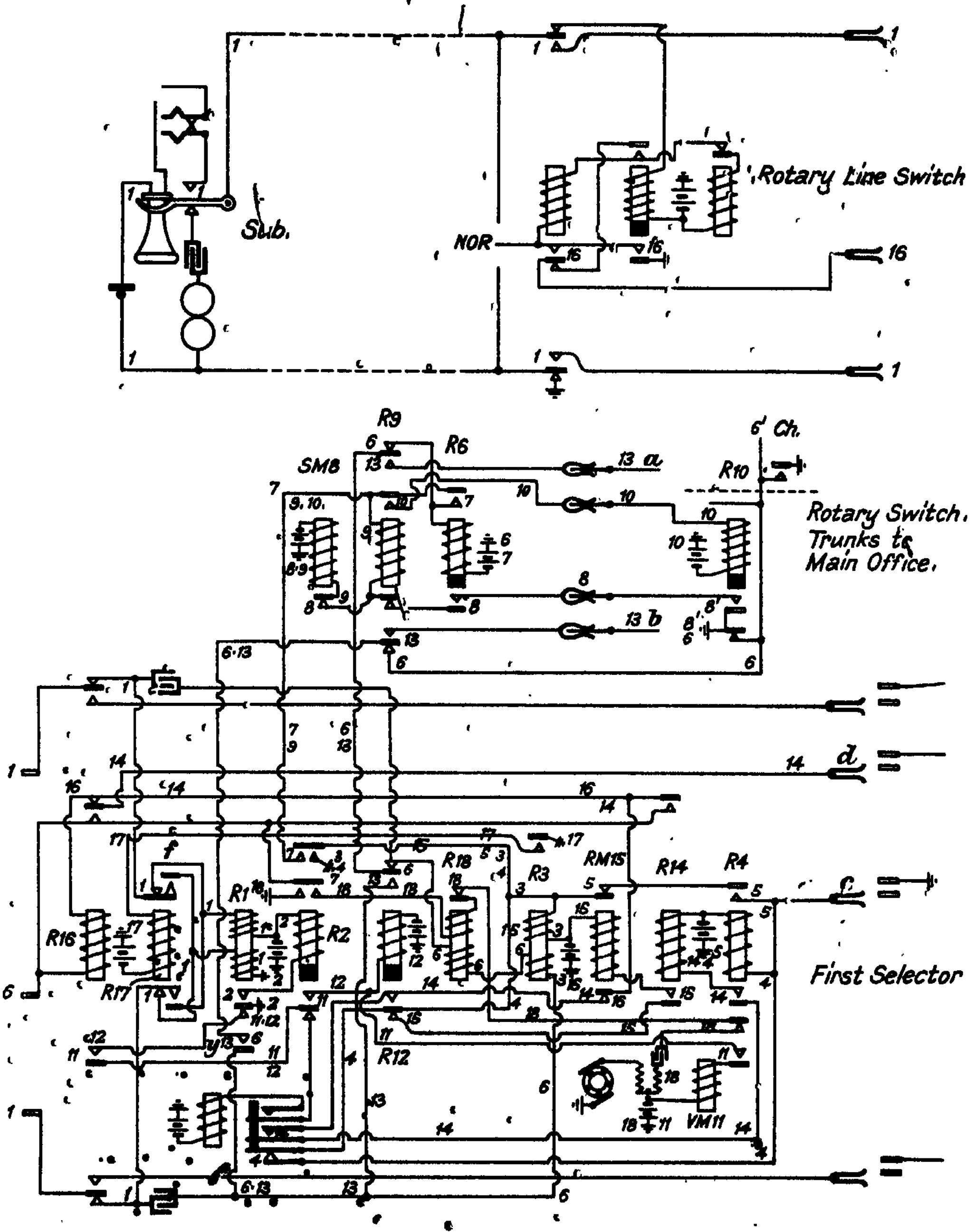


FIG. 64.—P.B.X. CALLING LOCALLY WITHOUT USING TRUNKS THROUGH CENTRAL (A. T. M. Co.).

16. When the test wiper *d* reaches the unearthed terminal of an idle trunk, the switching relay R16 energises (in series with R14 which does not energise) and opens circuit 1, so that R′ de-energises; then R2, R6, R9, and R10 de-energise. In the interval between the de-energisation of the last three relays, earth, over circuit 8, is connected to M8, to step the wipers to the next trunk.

A Call to the Main Office.—The operations are similar to those described up to the point where the selector shown takes its first rotary step. R4 then de-energises, because all the terminals corresponding to main office connections are blank. R14 circuit is open at R4. R16 circuit is also open, and the rotary movement is brought to a stop at once. Relay R′ is in circuit, so that succeeding impulses are repeated at contact *y* (circuit 13) over the trunk *a*, *b*.

17. When the call is completed and answered the reversal of current in the trunk *a*, *b* causes the polarised relay R3 to energise, because the currents in the two circuits now assist each other instead of neutralising. R17 then energises and reverses the current to the calling station.

Busy signal when all trunks are busy.

If all trunks to the main office are busy, no earth is connected to the wire *ch* and no circuit is completed when R′ is energised. The switch C′ is not set in motion.

18. When R4 de-energises, busy tone is through R18, which vibrates and induces a tone in the lower winding.

Section 29

A P.B.X. CONNECTOR ACCESSIBLE TO ORDINARY SELECTORS AND TOLL OPERATORS

Usually a toll connector is associated with a group of ordinary connectors. In P.B.X. or other satellite office, especially when these are small, it may be advisable to use connectors capable of performing both functions. According to this new circuit of the A. T. M. Co. (Fig. 65), when all lines of a P.B.X. group are busy, a busy tone is given to the caller without the wipers stepping over any terminals. Also, if the toll operator waits on the line, the connector will seize the first line that becomes idle.

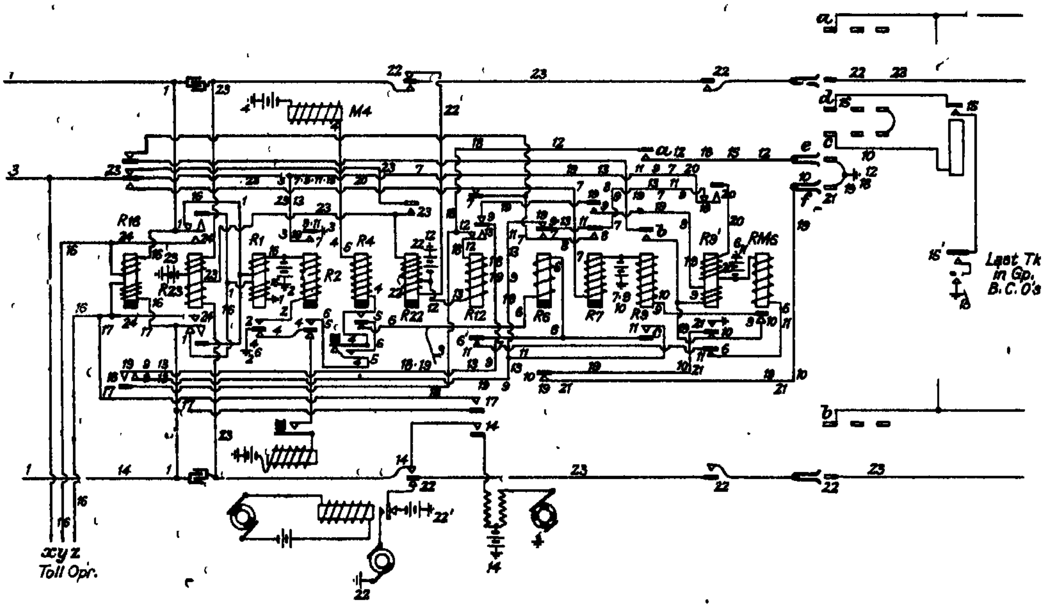


FIG. 65.—P.B.X. CONNECTOR USED FROM SELECTOR OR OPERATOR. BUSY TEST GIVEN WITHOUT HUNTING IF ALL LINES BUSY (A. T. M. Co.).

The circuits are numbered as follows :—

1. When a line is extended by a line switch and selectors to a connector, in known manner, R′ energises.
2. Guard relay R2 energises.
3. Release trunk and holding circuit made busy.

The subscriber dials for the branch office.—Terminals *a*, *b* are the first line of the group.

4. VM4 steps the wipers to the desired level. R4 energises for the duration of the impulses.
5. On the first step circuit 4 is opened at the off-normal contacts, and 5 completed. After the impulses, R4 de-energises and opens circuit 5.

Next digit impulses.

6. RM6 steps the wipers to the P.B.X. No. 1 terminal. R6 energises for the duration of the impulses.

7. R7 (slow) energises.

8. R7 locking circuit. After the impulses R6 de-energises.

9. R9 and R9′ do not energise in this circuit. When R9 does energise, contacts *a*, *b* lose before *c*.

Assume No. 1 trunk busy.—Private terminal *c* is earthed.

10. R9 energises.

11. RM3 energises and opens circuit 10 of the interrupter, relay R9 then de-energises. If the next terminal is earthed, R9 will again energise, in circuit 10, to again step the wipers, and so on until the last terminal of the group is reached, when earth will be on both terminals.

12. Busy relay R12 energises.

13. R12 locking circuit. Circuit 6 of RM6 is opened at 6′.

14. Busy signal to caller.

15. If all the trunks in the group had been busy, just prior to the last series of impulses, then earth would be on the first extra test contact, as the BCO relay of each trunk is energised. R12 would be energised, over circuits 15 and 12, and busy tone is given to the caller without the rotation of the wipers.

The connector can be taken into engagement by a toll operator over wires *x*, *y*, *z*.

16. R′ is energised in series with the windings of R16, which is differentially wound and does not energise. Further connections are as above up to circuit 15, all trunks busy.

17. Short-circuit about the lower winding of R16. Circuit 14 completed to give the busy tone. Circuit 6 open. Holding circuit 13 completed. R16 energises.

18. R12 new holding circuit, over wiper *e*. R12 is thus energised only so long as all trunks are busy, until earth is removed from wiper *e*. If the second trunk now becomes idle, contact 15′ will open. R12 then de-energises and completes circuit 6 to energise RM6, which will find the idle line.

19. Circuit for lower winding of R9′ to wiper *f*, then through BCO relay of second trunk to battery. R9′ energises.

20. R9′ locking circuit.

21. Wiper *f* made busy.

22. Ringing current to line. R22 does not energise until called subscriber answers. Circuit 22 opened.

23. R23 energises over loop. Connections reversed to R′.

24. Both windings of R16 short-circuited.

Section 30

OPERATION OF ONE-DIGIT GROUP CONNECTOR; SELECTIVE RINGING WITH SUPERIMPOSED CURRENT; RELEASE WHEN LAST PARTY HANGS UP. A. T. M. CO.

This circuit shows how access is given to a large group of lines on a plurality of levels without hunting over levels in which all lines are busy.

The circuits of Fig. 66 are numbered in the order of operation, as follows :—

1. When a calling line is extended to the switch R′(A) energises.

2. The slow-to-release guard relay R2(B) energises.

3. Earth is connected to the release trunk to hold the preceding switches energised.

First or tens digit impulses.

4. When R′ de-energises, when circuit 1 is opened, R4(C) energises, for the duration of the impulses, and the vertical magnet VM4 steps-up the wipers to the digit level.

5. A ½ mfd. condenser in series with a 10-ohm resistance to earth, at the winding of R4(C), prevents excessive sparking at the contacts of R′(A).

The 150-ohm non-inductive winding on top of and in parallel with the 4-ohm winding of R4 absorbs the inductive kick.

6. The off-normal springs ON close on the first vertical step. R6(G) is energised for the period of vertical impulsing.

The 1300-ohm non-inductive winding on top of and in parallel with the 200-ohm winding of R6, prevents excessive sparking at VM4 interrupter springs during impulsing.

7. Excessive sparking at springs of R6 are prevented.

8. After the dial impulses, R4 de-energises. R6 holding circuit.

9. If all the lines in the first level are busy, all chain relays are energised, and R9 energises.

10. When the vertical wiper finds an earthed terminal, R10(E) energises.

11. VM4 energises, to step the wipers to the next level (the automatic vertical impulses cannot operate until the dialled impulses cease, because R4(C) is energised). When VM4 energises, circuit 8 is opened, and R6 de-energises. If this bank contact is also earthed, by all lines being busy, circuit 9′ will be completed, and R9′ energised. R10(E) will be maintained energised over circuit 10–10′, and R6(G) will again operate, when VM4 closes circuit 8, which again energises VM4 over circuit 11.

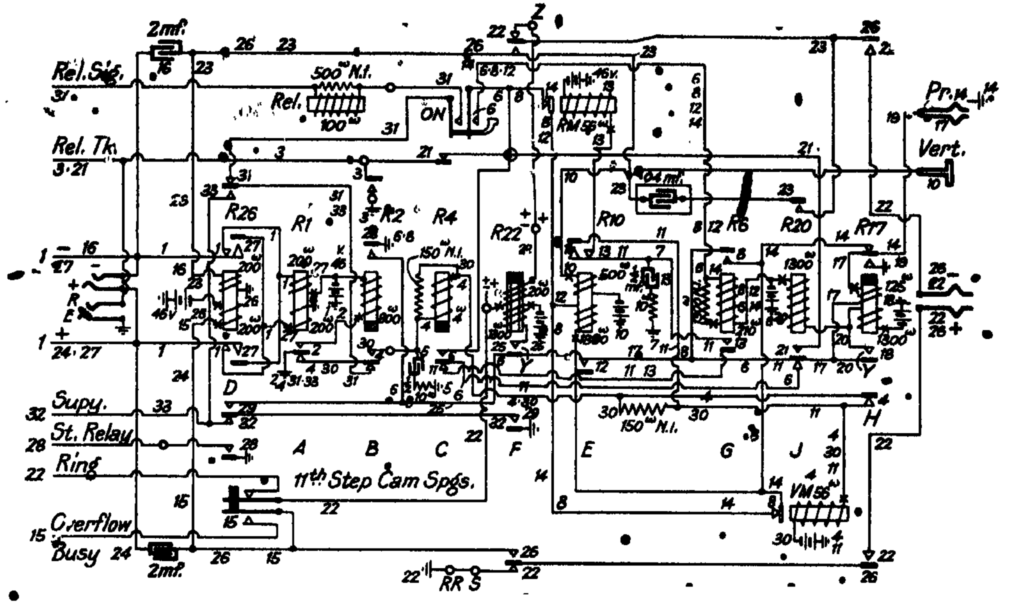
All trunks busy.

If all the levels associated with this group of trunks are busy, the wipers will be lifted to the last level, which is not provided with earthing chain relays, and there is, therefore, no earth on terminal 10″. R10(E), therefore, de-energises slowly (due to the induced current in the closed circuit 8–6 of its 1600-ohm winding).

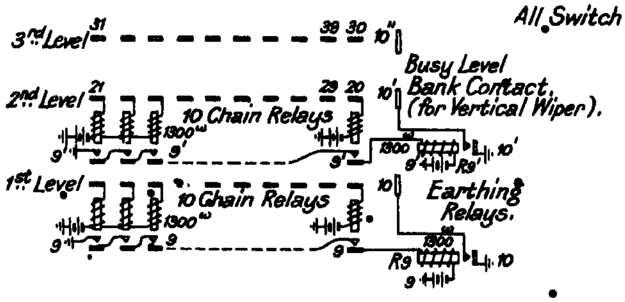
12 (partly over 6). During the brief period that the VM4 springs are closed, R10(E) is kept operated. Before R10 releases R6(G) will again operate, when circuit 8 is closed at VM4, and be held over circuit 8.

13 (partly over 11). When R10 de-energises, rotary magnet RM13 operates, and opens circuit 8 so that R6 de-energises.

14. If the first rotary line be busy, R6 will again operate. If all the trunks are busy, the wipers will rotate to the eleventh step. R6(G) cannot again operate, because there is no earth for circuit 14. The shaft now closes the cam springs.



Earthing and Chain Relays on Private Bank.
(Bank multipled as usual.)



Conventions and Notes.

All Switch Wiring to be No. 24 S.W.G. Switch Wire
Red — Earth Leads.
White — Battery Leads.
Green — All other Leads.

▮ Copper Slug on Heel End of Coil.
▮ Copper Slug on Arm End of Coil.
▮ Copper Slug on Arm End of Coil and Copper Sleeve on Core.
× denotes Inner End of Coil Winding.

Off Normal Springs to be adjusted to operate with First Vertical Step, just before Double Dog falls in.

Last levels in each group not equipped with chain and earthing relays for busying level.

10 Chain relays and 1 earthing relay common to each level and multipled to all connectors in unit.

Above circuit shows 1 group consisting of 3 levels.

FIG. 66.—ONE-DIGIT GROUP CONNECTOR CIRCUIT. SELECTIVE RINGING, WITH SUPERIMPOSED CURRENT. RELEASE WHEN LAST PARTY HANGS UP. (A. T. M. Co.).

15. Busy tone to relay D.

16. Induced busy tone to caller.

An idle line in the group.

If there is an idle line in any level the vertical terminal for that level is not earthed, and E10(E) de-energises. Before R10 has had time to de-energise, R6 will again energise, and lock itself over circuit 6. Circuit 13 is completed when R10 de-energises, and the first rotary step is made. RM13 energising, opens circuit 8, and R6 de-energises. If the first line is busy, R6 energises in circuit 14. R6 energises, and the rotary magnet makes another step. This cycle is continued until an idle line (*i.e.* one without earth) is found, when R6 will not be operated.

17 (partly over 6). R17(H) energises over winding of called party's BCO relay and battery.

18 (partly over 6). R17 locking circuit.

19. Direct earth to busy called line.

20 (partly over 6). R20(J) energises.

21 (partly over 6). Alternative earth for release trunk, to provide for "last party release" feature.

Circuit 4 is opened, to prevent VM4 being wrongly operated.

Ringing.

22. Interrupted ringing current to called line.

23 (partly over 22). Ringing tone through relay D.

24. Induced ringing tone to caller's receiver.

R22 does not energise until the called party lifts the receiver, because the copper sleeve on the core makes it insensitive to ringing current.

Called subscriber answers.

When the receiver is lifted, R22 energises, during the silent or ringing periods.

25. R22 locking circuit.

26. R26(D) energises, and feeds battery to the called party.

27. Current reversed to the calling line. R′ feeds current towards the calling line. The talking circuit includes the two 2-mfd. condensers.

28. Start relay circuit for booster metering.

29. Holding circuit for relays R22(F) and R17(H), should the caller clear before the called party.

Receivers replaced after conversation.

The connection is released when both parties replace the receivers. The caller, by replacing, can restore his line switch and the selectors, but not the connector.

30 (partly over 4). Caller's but not called party's receiver restored. R′ de-energises. R4(C) energises and opens circuit 21. R2 de-energises and opens circuit 3. Thus, momentarily, there is no earth on the release trunk, and the preceding switches restore. R2 opens circuits 4 and 30, and R4 de-energises. Earth is then replaced on the release circuit, over circuit 21-29, so that the connector is made busy to other callers.

31. When the called party now replaces the receiver, the release magnet energises, to restore the switch to normal, when the contacts ON are opened.

Excessive sparking at the ON springs is prevented by the 500-ohm non-inductive winding on the release magnet.

Supervisory circuits.

If the called party replaces his receiver, and the caller does not, R26(D) de-energises.

32. If the caller does not replace in a pre-determined time, a visual and audible signal is given.

33. If the caller replaces, and the called party does not, R2 de-energises. A signal is given as before.

In both cases the relay is common to a group of switches.

Section 31

FINAL SELECTORS FOR WORKING IN CONNECTION WITH BRANCH OFFICES (SIEMENS)

The final selector (connector) for P.B.X. working is an ordinary final selector, such as described in connection with Figs. 67 and 68, Vol. I. When used in the present application it has, in addition, an earth-connected metal arc tapped to accommodate a number of screws whose centres correspond to the bank contacts (Fig. 67, Vol. II). The screws project from the inside of the arc and over them a double wiper passes. An additional relay to control the drive circuit is also fitted.

The double wiper is so arranged that when one wiper is resting on the screw corresponding to the number dialled, the other wiper is resting on the screw corresponding to the previous number.

Screws are inserted in the holes, corresponding to the lines of P.B.X. groups, except the last line of the group. When the first line in a P.B.X. group is dialled, the first or leading wiper is resting on an earthed screw, whilst the second, or lagging, wiper is disconnected. Under these conditions a drive circuit is closed and is maintained until a free line is found, or until the last line in the group is reached. There being no screw corresponding to the last line, the circuit of the relay closing the drive circuit is disconnected, and the switch is stopped on that line. Should it be busy, busy tone is transmitted to the caller.

Night service is given on all lines in a P.B.X. group, except the first. Should at any time a P.B.X. line be dialled (other than the first line) the final selector tests that line, and if busy does not drive on, but gives busy tone to the caller.

Lines in one P.B.X. group must be consecutive and on the same level, but there are no other limitations. P.B.X. groups can be immediately adjacent, or be interspaced with ordinary individual subscribers' lines.

Operation of calling an individual subscriber's line.

Fig. 68 shows a final selector circuit for individual lines and small P.B.X. groups. The only variation from a standard individual line final selector diagram is shown to the right of contact N2, including relay R21(PR) and the wipers.

1. The preceding selector tests over the C wire and the holding relay R' energises.

2. R'(N) holding circuit, to make it independent of K'.

3. The testing relay at the preceding selector extends the A and B wires to the final switch. R3 energises over the B wire.

4. Dialling relay R4 energises.

5. The tens impulses are now received. R3 responds to these. R4 remains energised for the duration of the impulses. The vertical magnet VM5 steps-up the wipers to the correct level.

6. At the first step the K contacts are operated. R4 is maintained over circuit 6. At the end of the train R4 de-energises.

7. Guiding relay R7(G) energises, and transfers the impulsing contact A″ from the vertical to the rotary magnet.

8. R4(D) again energises.

9. R7(G) holding circuit.

10. The units impulses are now received, and RMS steps the wipers round the arc.

At the first step the W contacts are operated. R4 is maintained energised over circuit 6. At the end of the impulses circuit 6 is opened, and R4 de-energises.

11. Circuit 9 is opened and, during the slow release of R7(G), the called line is tested. Should the called line be free, R11(T) energises in series with the pre-selector T-relay, over the C wire.

12. R11(T) holding circuit. This low resistance circuit makes the called line test busy to other switches.

13. R13(S) energises.

14. Ringing current to called line.

15. Ringing tone to caller.

When the called party answers, R14(TR) energises.

16. Short-circuit about R13(S), so that it de-energises and opens ringing and tone circuits.

17. R14(TR) holding circuit.

Circuit complete for conversation.

Called line busy.

R11 does not energise, because the C wire is either disconnected or connected to battery through a low resistance.

The release of R7(G) opens the testing circuit 11, to prevent the operation of R11, should the line subsequently become free.

18. R14(TR) energises.

19. Busy tone to caller. Contact TR' (short-circuit 16) operates to guard relays R14(TR) and R13(S) against the release of A3. R3 is disconnected when busy tone is applied.

Release.—The final selector is released when the C wire (circuit 3) is disconnected at the preceding switch. R' de-energises.

20. R11 de-energises. Release magnet M20 energises. The selector returns to normal and restores the K and W contacts.

Circuit 14 is opened at W2, and the release magnet circuit at K2. Battery is connected to the C wire at K'.

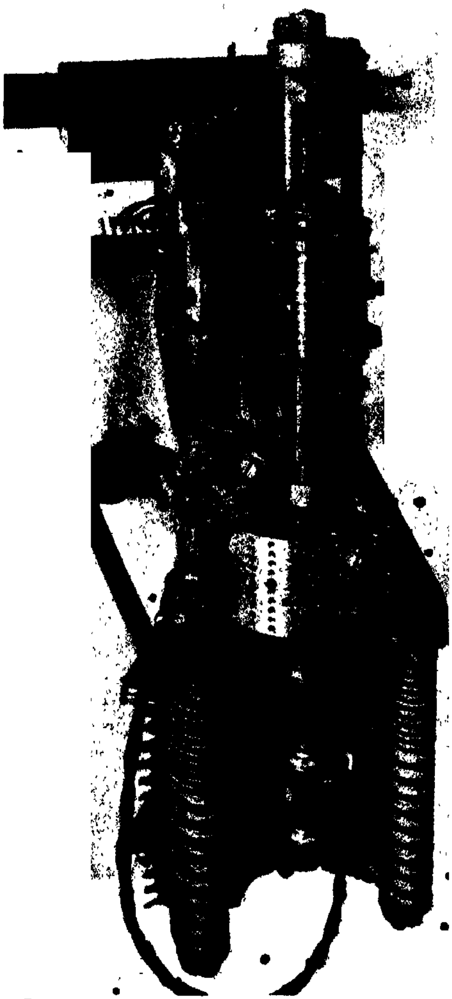


FIG. 67.—A P.B.X. FINAL SELECTOR (SIEMENS).

Circuit Operation of Small Groups of P.B.X. Lines (Fig. 68).

First line of group free.—The final selector responds to the tens and units impulses, and is stepped to the first line in the group in a manner identical to that above described.

21. When R4(D) de-energises at the end of the units impulse train, R11(T) and the extra relay R21(PR) circuit is completed. If the first line is idle, R11 energises and, at T',

opens circuit 21 so that R21 does not energise. In that case the connection is completed as described for an individual line.

If the first line in the group is busy, R11 does not energise, but R21(PR) energises, its circuit being completed over the screw in the P.B.X. arc.

22. R7(G) holding circuit, to maintain the circuit of the testing relay R11 during the search for a free line. Contact PR3 is opened, and disconnects the lagging wiper, which is only required for night connecting.

23. Rotary magnet RM10 energises, and steps the wipers round the level, each line being tested.

On the first free line R11 energises, and opens circuit 21, so that R21(PR) de-energises, and opens the drive circuit.

The subsequent operations are similar to those described for circuit 11, "Called line free."

All lines in the group busy.—The switch will then drive until the last line is reached, when R21(PR) will de-energise, because there is no screw for that line in the arc. Circuit 23 is opened.

Circuit 22 is opened. R7(G) de-energises, and the subsequent operations are as described in "Called line busy" above.

Circuit Operation for Night Service.—Each line, except the first, is available for night service, and connection therewith is obtained by dialling its particular number. The operation is similar to that of an individual line, described above, since relay R21(PR) is rendered inoperative, because of the short-circuit over PR3 to earth, at the screw in the P.B.X. arc corresponding to the preceding line.

Operation of the Final Selector for Large P.B.X. Groups.

The final selector is similar to that described for small P.B.X. groups, but the provision of two additional relays, and a rotary release magnet, enables the switch to return to a rotary normal position, and step-up to and search along the next level. When the switch has searched over a level, in which all lines are busy, it rotates back over the level. As soon as the rotary release is complete, two impulses, one vertical and one rotary, are given, which step the switch to the first line of the next level, and searching is continued. Thus the switch can search over all the ten levels, if required.

Night service, *i.e.* the facility of calling any line of the group without searching, can be given on all lines in the group, except the first line in the group, and the first line in each level.

Circuit Operations (Fig. 69).—Only the additional circuits are numbered in this diagram, with a few others specially referred to. For the general operation, Fig. 68 must be referred to.

When all the lines in one level are busy, the switch drives to the eleventh contact. Relay R21(PR) de-energises, because there are no screws in the arc corresponding to these. The drive-circuit 23 is opened and R7(G) released.

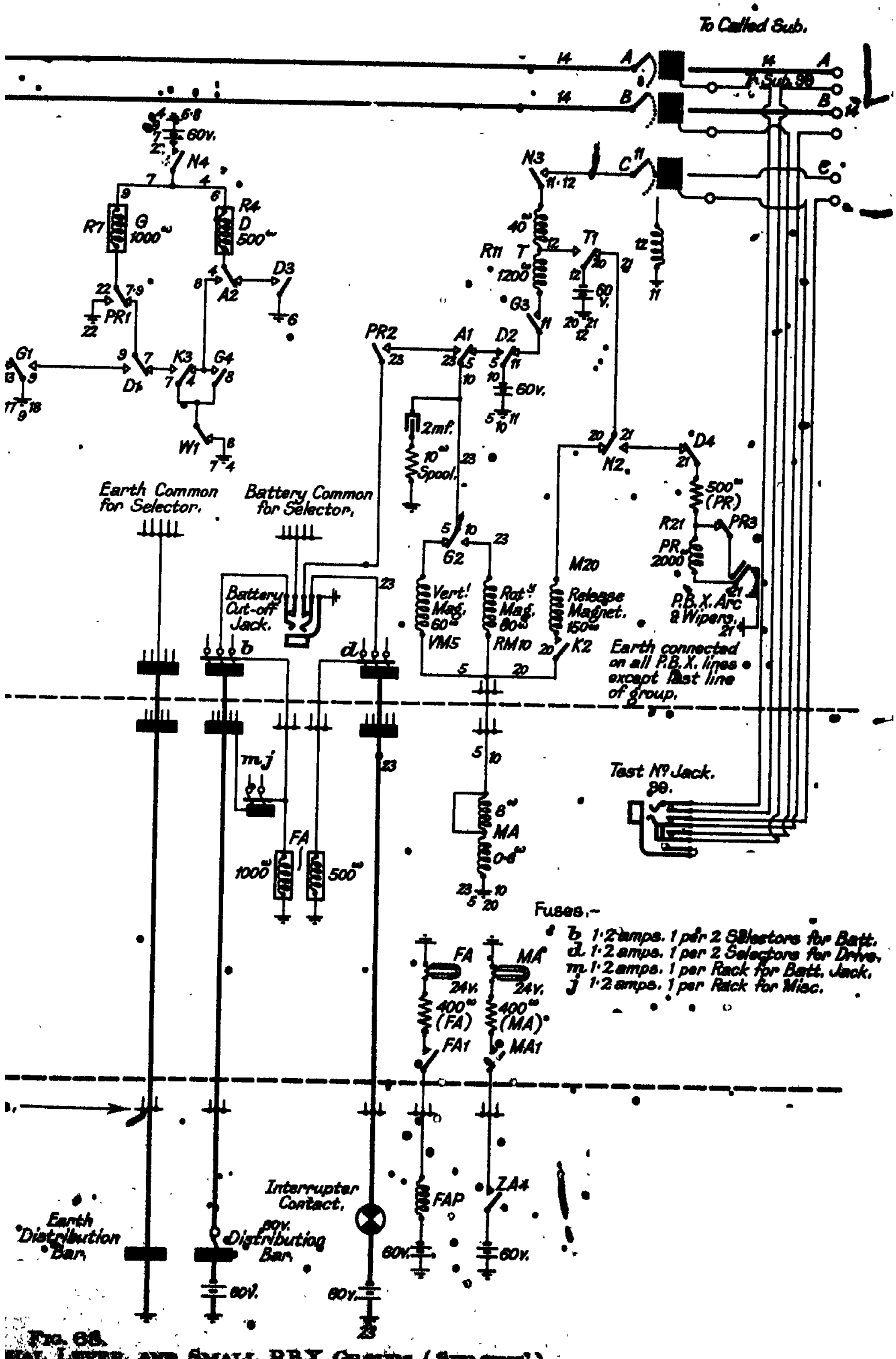
24. R11(T) and R24(PS) energise in series. R3(A) de-energises and remains inert until the switch reaches the first line in the next level.

25. R25(PT) energises in series with the holding coil of R24.

26. Contact PT4 (24′) opens the circuit of R11(T), which de-energises.

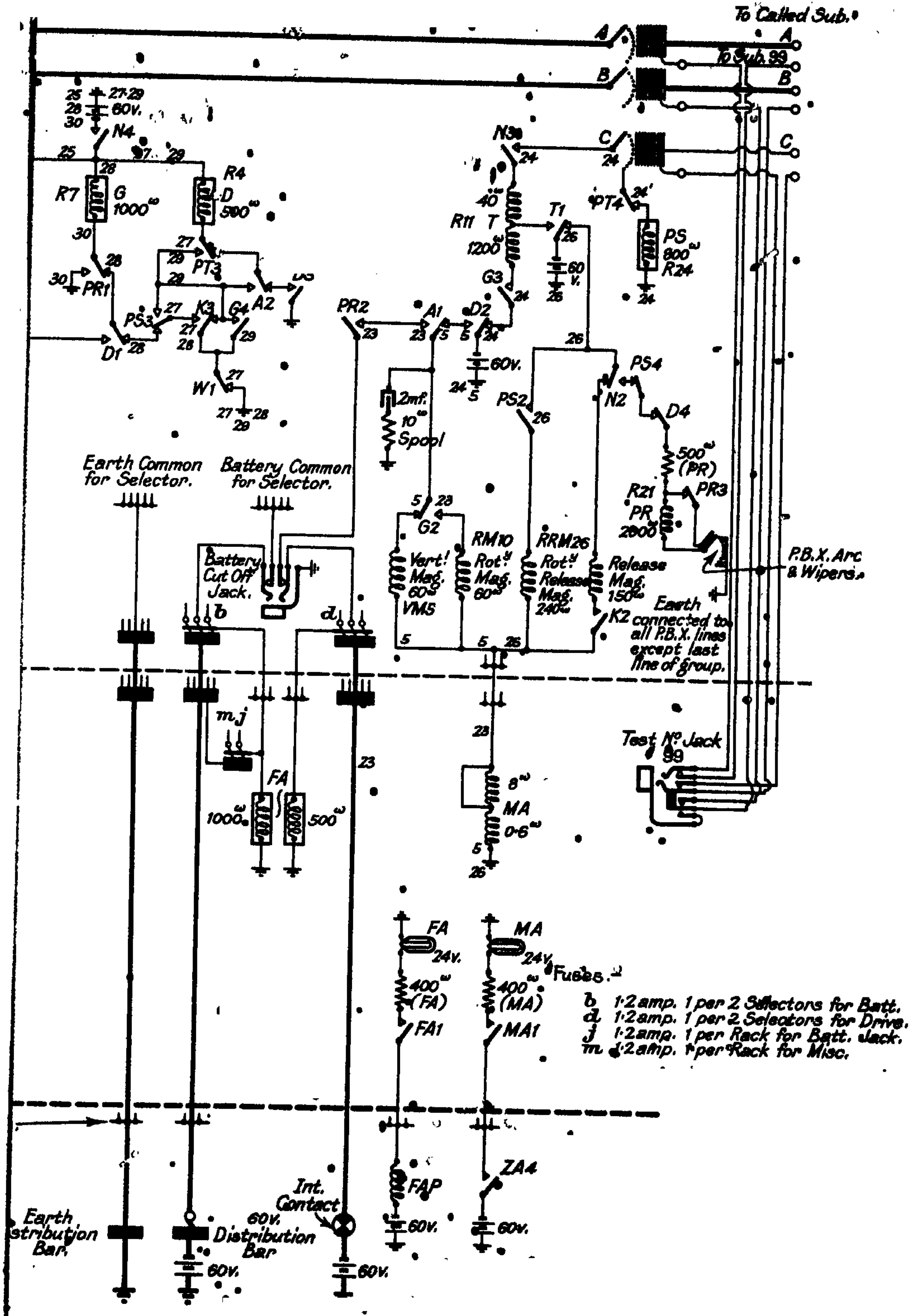
Rotary release magnet RRM26 energises, and the switch is returned to the rotary normal position, when the W contacts return to normal.

27. R24(PS) is disconnected, but remains operated sufficiently long for R4(D) to energise. An impulse is now given to the vertical magnet VM5, over circuit 5.



Fuses.–
- b 1·2 amps. 1 per 2 Selectors for Batt.
- d. 1·2 amps. 1 per 2 Selectors for Drive.
- m. 1·2 amps. 1 per Rack for Batt. Jack.
- j 1·2 amps. 1 per Rack for Misc.

FIG. 68.
AL LEVER AND SMALL P.B.X. GROUPS (SIEMENS').



IT FOR LARGE P.B.X. GROUPS (SIEMENS').

28. R4 de-energises, and completes a circuit for R7.

29. R4(D) again operates to give an impulse to the rotary magnet.

The rotary off-normal contacts W are now operated. R4 de-energises, also R25(PT). The rotary-magnet circuit is opened. Circuit 21 is closed over the arc screw of the first line in the level. R21(PR) energises and, on the operation of R3(A), subsequent to the release of the relay PT, the drive-circuit 23 for the rotary magnet is again closed.

30. Holding circuit of R7(G), which completes the testing circuit 11 of relay R11(T).

The operation on reaching the first free line, or on reaching the last line in the group, is as already described.

Circuit Operation for Night Service.—The operation is similar to that described for small P.B.X.'s. When a switch is standing on the first line in a level, the wiper to which PR3 is connected is not standing on a screw. It follows, therefore, that the first line of a level, like the first line of a group, is not available for night service.

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Section 32

AN "ALL-RELAY" SYSTEM PARTICULARLY APPLICABLE TO SMALL INSTALLATIONS

In small offices, simplicity of apparatus and circuits is essential. An all-relay system attains simplicity of apparatus at the expense of multiplication of relays and complication of circuits. It will be noted from the diagram that the preselection of an idle connection-circuit to join two lines together is most simple and efficient, but that the connection-circuits are overburdened with relays, which might be readily replaced, to a large extent, by a simple stepping device. The circuit is interesting in showing how the cycle of operations in four relays energises a relay for every impulse of a digit, so that this relay can be made the connecting relay to the called line.

The arrangement is most suitable for small exchanges having a capacity up to 28 lines, but may readily be increased. The diagram shows the circuits of a 19-line switch having three "connection-circuits" to allow of three simultaneous conversations. These can be increased as required by the traffic. Fig. 70 shows the A. T. M. Co. circuit.

The calling line switch directly connects a calling line with a connection-circuit or trunk, and has no intermediate circuit or testing apparatus. It is a true preselector, as the trunk to be connected to is determined by the prior connections, and is instantly completed without the aid of common apparatus. Each line is equipped with as many simple relays as there are trunks, one side of the energising winding being connected to battery, through a contact on the guard relay, and the other side connected to earth, when the line relay energises on a call. The connection to the relay above is through a back contact on the lower relay so that when the lower relay energises, it cuts off earth from those above, so that they do not energise. If the lower relay fails to energise, because battery is cut off at the guard relay, then the relay immediately above will energise, and so on. There is in addition the usual line and cut-off relays per line. For incoming calls each line has a relay associated with each connection-circuit, and these relays also act as counting relays in a manner to be described.

Each connection-circuit has six relays for battery feed, ringing and control, and four repeating or impulsing responding relays which operate in a cycle in such a way that only one relay per impulse is required. Alternate counting relays are connected to different energising wires from the impulse relays, which are associated with odd and even numbers of impulses, and numbered 1 to 9 and 01 to 00 in a 19-line equipment, to agree with the subscribers' numbers. Relay 0 is a switching relay to bring into operation a second holding circuit.

Other features will be described in the operation of the circuits.

The circuits are numbered in the order of operation as follows :—

1. When the receiver of S is lifted R′ energises. Assume No. 1 connection-circuit busy, that is, circuit 2 open. Assume No. 2 to be called.
2. Connecting relay R2 energises.
3. Impulse and feed relay R3 energises over loop.
4. Guard relay R4 energises. Circuit 2 is opened and connection-circuit 2 is made busy to other callers.
5. Cut-off relay R5 energises. R′ de-energises.
6. R2 holding circuit.

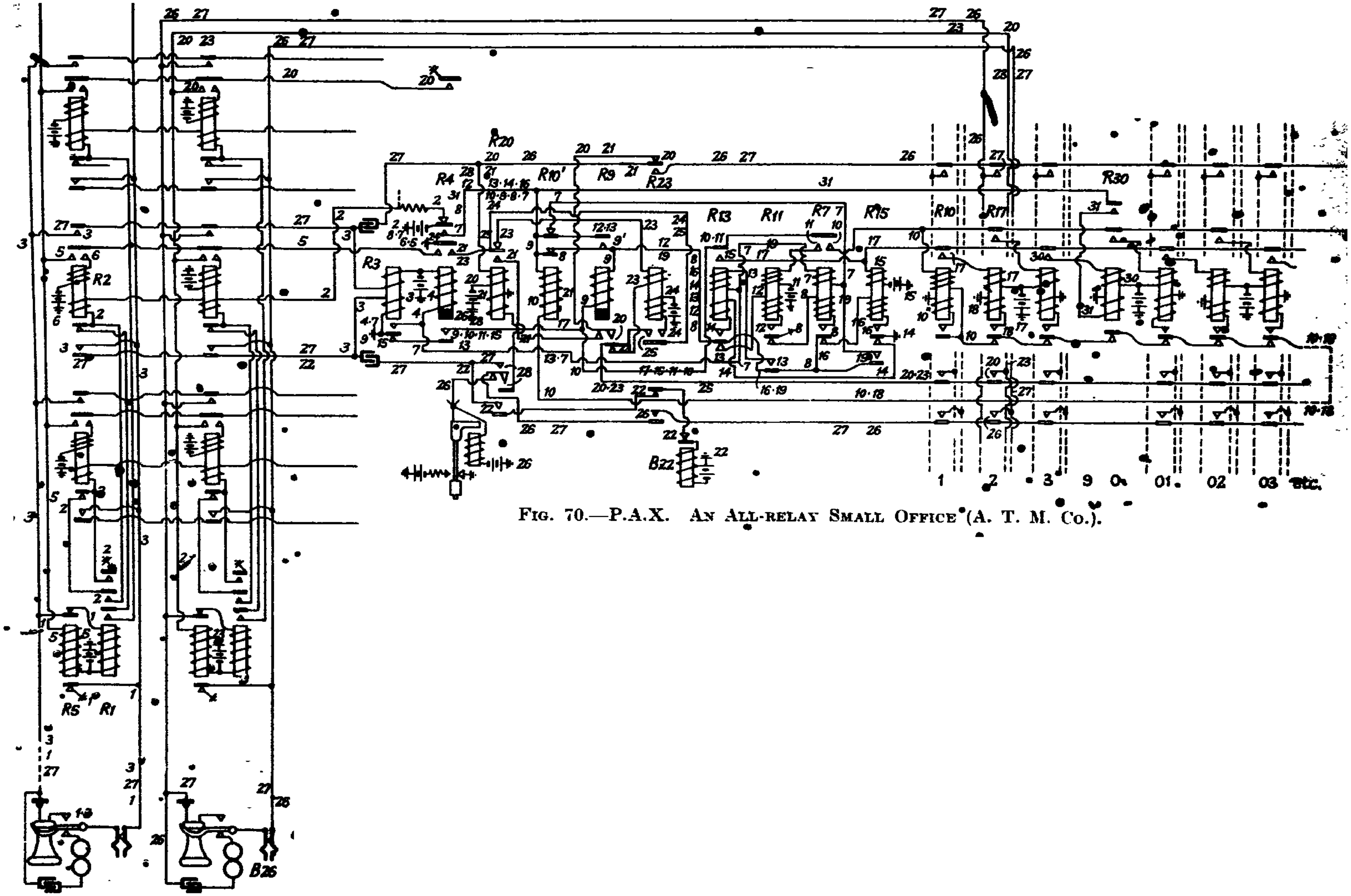


FIG. 70.—P.A.X. AN ALL-RELAY SMALL OFFICE (A. T. M. CO.).

7. Repeater relay R7 energises.

8. R7 holding circuit.

9. Impulse relay R3 de-energises on first break at dial. R9 energises for the duration of the impulses.

9′. New path to battery.

10. First counting relay R10 energises; also R10′ to open circuits 7 and 8. The latter remains closed over 9′.

10″. R10 holding circuit.

11. Repeater relay R11 energises. Opens circuit 8 and R7 de-energises. Opens circuits 10 and 11.

12. R11 holding circuit.

13. R3 re-energises at the end of the first impulse and R13 energises. Circuit 12 open. R11 de-energises. Circuit 13 opened.

14. R13 holding circuit.

End of first, or odd number, impulse 1.

15. R3 de-energises on break at dial for second impulse, R15 energises.

16. R15 holding circuit.

17. Second counting relay R17 (even) energises.

18. R17 holding circuit in series with R10′. Circuit 10 open and R10 de-energises.

R3 re-energises at end of impulse.

19. R7 re-energises, partly over circuit 7, circuit 16 opens and R15 de-energises.

8. R7 holding circuit. Circuits 10 and 11 are prepared for the next impulse (if any).

20. If line No. 2 is busy R20 will energise over the holding circuit.

21. R20 holding circuit.

22. Busy tone is given to caller.

If the line is idle R20 is not energised and ringing current is applied.

The number having been called, R9 de-energises. R10′ remains energised. Circuit 8 is open and R7 de-energises.

23. R23 energises to complete the loop.

24. R23 holding circuit.

25. Called line made busy.

26. Ringing circuit to called line. R20 does not energise until called party answers. Ringing is by polechanger, in which the pendulum connects battery and earth alternately to line, about twenty times per second. Ringing is cut off when R20 energises.

27. Loop talking circuit, current fed through R3.

28. Battery feed for called party through R20.

The connection is broken down when the caller's receiver is replaced, when R3 and R4 de-energise.

30. When 0 is dialled (ten impulses), R30 energises, partly over circuit 17.

31. R30 holding circuit. Circuit 18 is open to de-energise all counting relays of lower value and succeeding relays are built up by impulses as before described.

A connection has thus been completed between the two telephones shown, over the contacts of R2 of the calling line and R17 to the called line. The talking circuit is divided by condensers and battery fed to the calling line over R3 and to the called line over R20. The transmission efficiency is standard.

Section 33

AUTOMATIC INSTALLATIONS FOR WORKS, WAREHOUSES, OFFICES, AND THE LIKE

These are, generally, very similar to the exchange systems described, but are considerably simplified by the elimination of meters, impulse-repeaters, selectors, and other special apparatus.

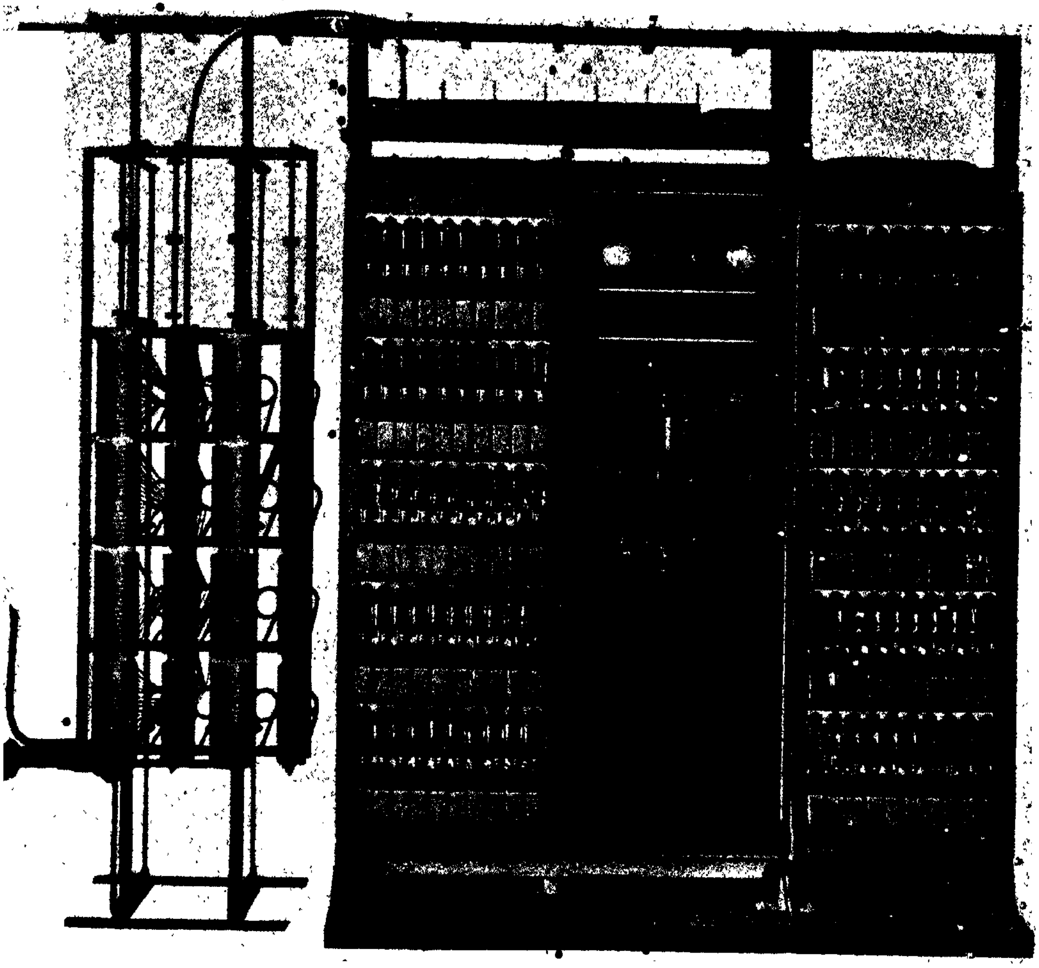


FIG. 71.—ONE-HUNDRED LINE P.A X. (A. T. M. Co.).

In a 100-line installation there are 100 line switches (1 per station), and 7 to 12 connectors, a multiple of the 100 lines being carried over the latter. In some cases the line switch and the connector are combined.

For installations of over 100 lines there must be some form of selector or discriminator to differentiate between one 100 and another.

The instruments are usually similar to those used on the public systems, and when the transmission devices also equal the public exchange standard, connection may be had with the public exchange on approval by the Post Office. When such service is to be given to a proportion of the total lines, it is sometimes required that it be made impossible for the remainder to connect with the exchange, and devices can be introduced to limit this service.

For small exchanges of 20 lines and upwards the automatic system is replacing the well-known "inter-communication sets." The advantages are: the elimination of the large cable which has to be multipled over all stations in the latter system, the automatic requiring, usually, only two wires from each station to a central point; the simpler instrument at each station, with the switching apparatus at a central point, the greater reliability of the switching, the secrecy devices, and the freedom from overhearing.

Fig. 71 shows a 100-line unit of the A. T. M. Co. using their 25-point rotary switch, described on p. 39, Vol. I. The switch would not be used to its capacity, except in exceptional circumstances, as only 7 to 12 connectors are necessary on the average installation per 100 lines. The connectors are of the standard exchange type with certain simplifications.

The connectors are fitted at the rear of the frame.

Section 34

PRIVATE AUTOMATIC EXCHANGES (P.A.X.) AND BRANCH AUTOMATIC EXCHANGES (B.A.X.), STROWGER SYSTEM, A. T. M. Co.

Private exchanges may be of any size, from 10 lines upwards.

They are primarily designed for installation in works, offices, and the like, for rendering quick, accurate, and secret intercommunication, without the assistance of an attendant.

Not only does a P.A X. serve all the ordinary telephone requirements, but it may be arranged with additional equipment to render a number of special services, such as conference facilities, urgency calling by code when a party is out of his office, watchmen's control, fire alarm, and other auxiliary services as will be described.

These small installations may also be fitted with apparatus to enable service to be given and received over the public exchange, and they actually then become part of the great public-service system.

A 50-line P.A.X. equipment consists of one switchboard, upon which all the automatic and power-switching equipment is mounted, enclosed in a cover of steel and glass construction; also one junction box (for terminating and connecting the subscribers' lines to the automatic switchboard) charging plant, batteries, and battery cabinet.

The 100-line P.A.X. equipment consists of two units, viz. one automatic switch unit, and one combined M.D.F. and power-panel unit, both enclosed in a steel and glass cover; also a charging plant, batteries, and battery cabinet.

Types of P.A.X. and B.A.X. Equipment.—Naturally these vary according to the requirements of the owner and depend on local conditions, but these will be found to be covered by the seven following types :—

1. Isolated, self-contained, and fully automatic.

2. Similar to No. 1, but with an attendant's cabinet. An attendant is at all times available to answer enquiries, or perform other like services. The attendant's cabinet is provided with incoming and outgoing trunks to the P.A.X. equipment.

3. Similar to No. 1, but connected with the public-exchange system.

The switchboard is equipped with incoming connectors, the banks of which are multipled with the banks of the local connectors. The B.A.X. subscribers' numbers are listed in the Public Directory. At the public exchange one or more selector levels, depending upon the size of the B.A.X., are connected to the trunks incoming to the B.A.X. Incoming trunks from the main office (automatic) are individual to each unit of the B.A.X., so that a subscriber at the M.A.X. calls any B.A.X. number by dialling the last two digits of his number, first prefixing the proper digits to reach the outgoing B.A.X. selector levels at the main office, as 4567–29. Outgoing trunks from the B.A.X. to the M.A.X. terminate on connector or first-selector banks at the B.A.X., and in line switches at the M.A.X. Each trunk is equipped with a repeater at the B.A.X. A B.A.X. subscriber, when calling a telephone connected to a M.A.X., does so in the usual way, with the exception that, before calling a number as it appears in the Public Directory, he calls a preliminary digit, which is required to place the wipers of the B.A.X. connector or first selector in connection with the bank contacts of an idle outgoing trunk.

Discriminating or Restricted Service.—It is sometimes necessary to restrict certain lines to local service only. Stations are prevented from receiving incoming trunk calls by earthing the private bank contacts of restricted lines at the incoming trunk connector bank terminals, and providing a busy tone to the caller. This is effected by the use of a resistance coil in parallel with the bridge cut-off relay winding of each line switch, arranged to have outgoing trunk service, and a special type of repeater on the outgoing trunks. The repeater in this case has a discriminating service relay, of low resistance, and so adjusted that it will only be energised to close the trunk contacts when it receives increased current from line switches which have the BCO in multiple with the resistance coil aforementioned. If this relay does not receive sufficient current to close the trunk contacts it remains normal. A busy tone circuit is closed through the positive side of the line and furnishes a busy tone to the caller.

4. A branch office with an attendant's cabinet for outgoing and incoming calls with the public system. For local operating reasons, and to supervise and control outgoing and incoming calls, it is sometimes advisable to have an attendant's cabinet. Provision is made in the attendant's cabinet for a complete series multiple of all subscribers' lines, so that the operator may be able to reach any subscriber, as in a manual C.B. office. The attendant's cabinet must, further, be equipped for double supervision for both incoming and outgoing calls. The trunks from the public offices are plug-ended.

On an incoming call the attendant ascertains the desired subscriber from the operator at the main office, and plugs the call through to the multiple jacks.

For outgoing calls the attendant's cabinet is equipped with one or more enquiry trunks, over which the operator ascertains the number, and requirements, of the caller and, if he wishes outgoing service, immediately plugs his line through on an idle trunk to the main office.

Discriminating arrangements consist in the omission of the restricted subscribers' lines from the multiple jacks.

5. A branch automatic switchboard with direct outgoing trunks to the public service, but with incoming trunks intercepted at an attendant's cabinet and extended through a multiple. The attendant's cabinet is identical with the type described in paragraph 4. Outgoing calls are handled as in paragraph 3, and incoming calls as in paragraph 4.

6. A branch switchboard connected to a public manual office, with both-way calls passing through a special B position. In general, this type of switchboard is the same as that described in paragraph 4, except that, instead of having an attendant's cabinet, located on the same premises with the automatic equipment, it is virtually transferred to the public office, where it is known as a special B position.

This special B position must be equipped with a dial-impulse sender, and have double supervision on the trunks to the B.A.X. If the operator wishes to extend a call, she plugs into a jack connected to a trunk, terminating in an incoming connector or selector at the B.A.X., and, by the operation of a key, associates the position dial with the trunk and calls the B.A.X. subscriber's number. When this called party answers, a supervisory lamp at the operator's position glows, and remains glowing until the receiver is replaced. Outgoing calls from the B.A.X. to the manual main office are made by the caller dialling one digit, usually 0, on the connector, or first selector, which connects the line through a repeater to the special B position, there glowing a lamp to attract the attention of the operator, who then completes the call in the usual manner.

Discriminating service may be provided on both incoming and outgoing calls, as described in paragraph 3.

7. A branch switchboard connected to a manual main office, with direct discriminating outgoing service, but with incoming calls passing through an attendant's cabinet. The outgoing calls pass through repeaters from the connector, or first selector, levels, and give the usual lamp signal to the main office operator. The operator treats these as calls from a subscriber's line, in the usual manner. The discriminating service on outgoing calls may be obtained by using the means described in paragraph 3. Incoming calls from the main office are intercepted by the attendant, who extends them into the B.A.X. by means of automatic switches.

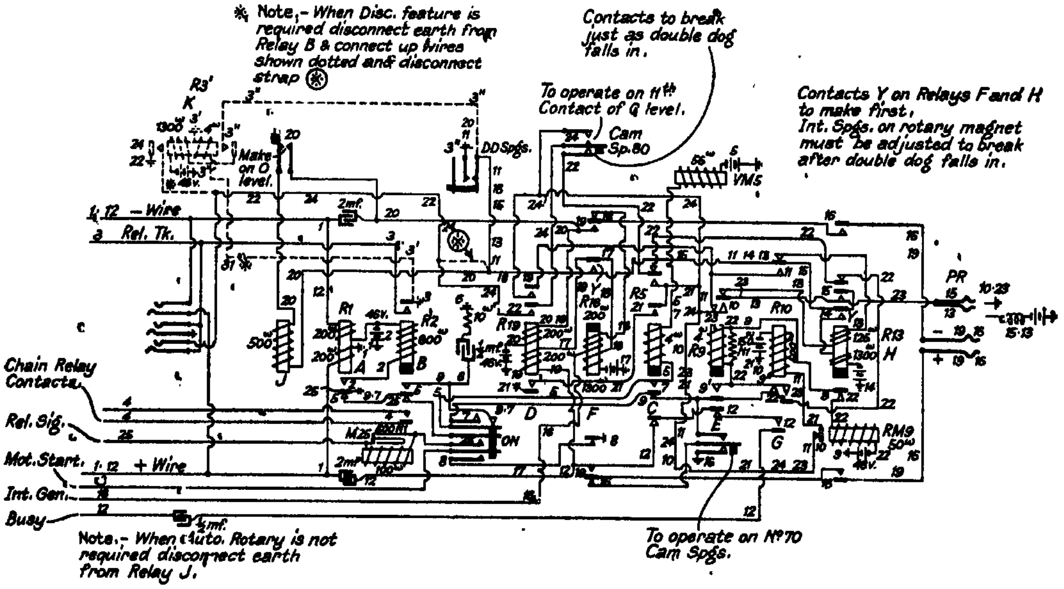
For this class of service the trunks from the main office are key-ended, and each has a connector, or selector, individually associated with it. The attendant extends the incoming call by associating the position dial with the trunk and calling the desired number. Discriminating service on incoming calls would be at the discretion of the attendant.

Section 35

SWITCHES FOR P.A.X.—THE CONNECTOR

The circuits of the P.A.X. connector (when used without selector, and with rotary on the 0 level) Fig. 72, are numbered in the order of operation as follows:—

1. When the calling line is extended to the connector R′ (A) energises.
2. Slow-to-release guard relay R2 energises.
3. Earth on release trunk to hold preceding switches.
4. Chain relays circuit closed.



✻ Note.—When Disc. feature is required disconnect earth from Relay B & connect up wires shown dotted and disconnect strap ✻

Contacts to break just as double dog falls in.

To operate on 11th Contact of 0 level.

Contacts Y on Relays F and H to make first.
Int. Spgs. on rotary magnet must be adjusted to break after double dog falls in.

Note.—When Auto. Rotary is not required disconnect earth from Relay J.

To operate on No. 70 Cam Spgs.

FIG. 72.—CONNECTOR FOR P.A.X.'S WITHOUT SELECTORS. ROTARY ON TOP LEVEL (A. T. M. Co.).

5. When the caller dials the tens digit, R′ de-energises and re-energises. At the first opening of circuit 1, R5 and VM5 energise. R5 remains energised for the duration of the train and VM5 steps-up the shaft as many levels as there are impulses.

6. Excessive sparking preventive device.

7. On the first step of the shaft the ON springs close, and, after the first impulse, this circuit is closed for the impulses.

8. Earth on motor-start relay, which closes a circuit for the ringing generator.

9. After the last vertical impulse, R5 de-energises and completes this circuit for the rotary impulses.

The units digit is dialled, and R9 energises for the duration of the train; RM9 steps the wipers round to the line required. Circuit 6 again prevents excessive sparking at contact of R′. During impulsing, the 9′ contact of R9 short-circuits the contact on relay G, to provide an alternative path for the rotary impulses, should relay G momentarily energise through the private wiper passing over engaged contacts during rotation.

10. Circuit of R10(G) as above. If the desired subscriber is busy, earth is on the private wiper, and this circuit is effective, because R9 is held operated by its slow release feature.

11. When R9 de-energises, R10 is held energised. The rotary magnet circuit 9 is held open at 9″ of R10, to prevent the operation of R13(H), should the caller restore whilst the connector is locked up on the busy circuit.

12. Busy circuit to caller.

13. If the called party is idle, R13 energises, when R9 de-energises, over the BCO winding of the called line switch to battery.

14. R13 holding circuit.

15. Called subscriber's line made busy. The BCO of the called party's line switch operates in series with R13, and is now held over circuit 15, and the called line relay is cut off. Circuit 9 is open to prevent further rotary motion should the caller dial again in error.

16. Circuit to line for interrupted ringing current.

17. Ringing tone to caller. R16 energises when the called party lifts his receiver to answer the call, and the ringing is cut off.

18. R17 locking circuit. Circuit 8 to motor start is opened.

19. Battery-feed relay R19 for called party energises. Current for caller is fed through R′.

Code Call Facility.—When this is provided cam springs are fitted, to operate on the number allocated for code-call circuit (marked 70 on diagram). These cam springs operate to disconnect the ringing circuit, and to extend the " impulse " circuit through to the code-call cabinet, *via* the positive wire and wiper.

Out-trunk Service.—In order to provide a discriminating feature for out-trunk service in this connector, cam springs are fitted, to operate when the connector wipers reach the level allocated for " out-trunk service."

A subscriber who has this service has a 46-volt battery, in series with a resistance placed in parallel with the BCO, on the private wiper of his line switch, which, when extended to the connector, operates the discriminating relay R3′(K) over circuit 3 plus 3′. 3″ is the holding circuit of R3′.

20. When the wipers reach the out-trunk level, say 0, the discriminating cam springs operate, and R19 energises.

21. R10(G) energises.

11. R10 locking circuit.

22. Slow-to-release relay R9 and rotary magnet RM9 energise, and the wipers make the initial rotary step.

23. If the first trunk is busy, earth will be on contact and R10(G) energises. The rotary magnet again operates as before. This cycle of operations continues until an idle trunk is found. When the wipers rest upon an idle trunk, the station is rung, as before described. Should all the trunks be busy, the busy cam springs will operate on the eleventh step, and open the rotary-magnet circuit.

24. R10(G) energises.

12. Busy circuit to caller, to indicate that all trunks are engaged.

A subscriber who has not the right to out-trunk service has no supplementary battery on the private wiper of his line switch, therefore he cannot operate relay R3′(K) to close circuit 22 to the rotary magnet.

20. When the wipers reach the 0 level, the discriminating cam springs close circuit 20 for R19(D), which energises.

21. R10(G) energises, but, as R3′(K) is not operated, 22 is not closed, but 12 is opened to give the busy tone.

25. When the calling receiver is replaced, R1 then R2 de-energise, and release magnet *Rel.* M25 energises to restore the shaft. Circuit 25 is then opened. N.I. winding prevents excessive sparking.

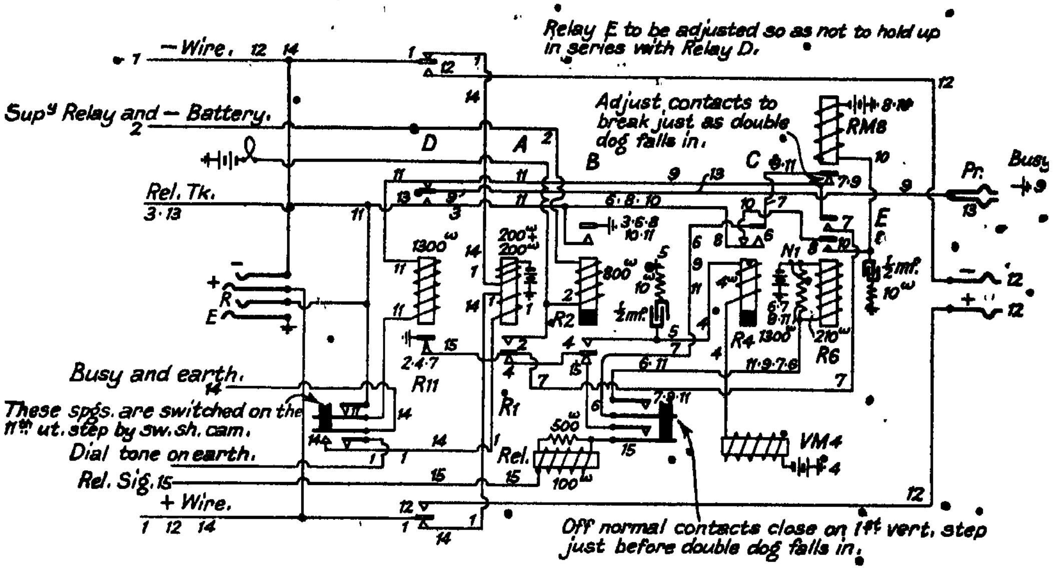
Section 36

OPERATION OF 10-LEVEL 10-TRUNK GROUP SELECTOR (Fig. 73)

The circuits are numbered in the order of operation as follows :—

1. When the calling line is extended to the selector R′ energises.
2. Guard relay R2 energises.
3. Earth on release trunk to hold preceding switches.

If dial tone is heard, the dial may be turned.


Relay E to be adjusted so as not to hold up in series with Relay D.

Adjust contacts to break just as double dog falls in.

These spgs. are switched on the 11th ut. step by sw. sh. cam.

Off normal contacts close on 1st vert. step just before double dog falls in.

FIG. 73.—TEN-LEVEL TEN-TRUNK GROUP SELECTOR (A. T. M. Co.).

4. R′ de-energises for each impulse of a digit. R4 energises for the duration of the train, and VM4 lifts the shaft one step for each impulse.

5. Prevents excessive sparking at R′ contact during impulsing.

Off-normal springs are closed at first step.

6. R6 energises.

7. R6 locking circuit. R4 de-energises.

8. RM8 steps the wipers to the first set of terminals and opens circuit 7 and R6 de-energises.

The 1300-ohm non-inductive winding on R6 serves to neutralise self-induction in this relay.

8′. Prevents excessive sparking at contact of R6.

Selection of an Idle Trunk.—If the first trunk is busy, the private wiper will find earth on the private bank contact.

9. R6 energises and closes the rotary magnet circuit.

7. R6 locking circuit.

10. RM8 energises and steps the wipers to the next terminal, and opens circuit 7 so that R6 de-energises. If this trunk is also busy, this operation will be repeated until a line is found without an earthed terminal. The earth on the private wiper also shunts relay D(R11).

11. R6 cannot energise, and R11, not being shunted, energises.

R6 is in series, but does not energise owing to its low resistance.

12. Talking circuit extended to the connector. R' and R2 de-energise. Earth is removed from the release trunk (circuit 3).

13. The preceding switches are now held by the switches ahead.

If all trunks in the level are busy, the wipers step to the eleventh position, when the cam springs operate.

14. Busy tone on the caller's line.

Release.—When the receiver is replaced, earth is removed from the release trunk and R11 de-energises.

15. *Rel.*15 energises and restores the selector to normal, when the shaft opens this circuit.

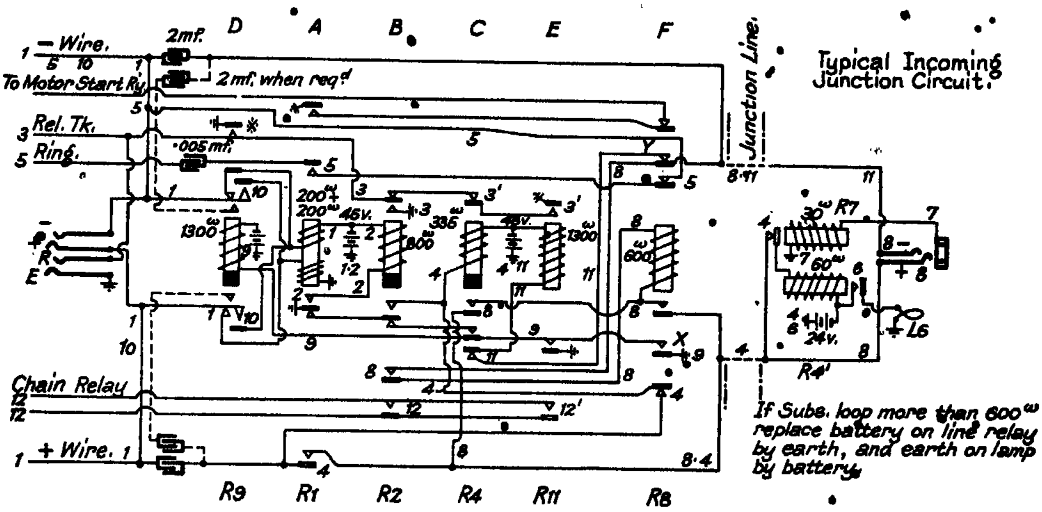
All selectors are connected to a supervisory signal which glows as a switch is taken into use. All first selectors have in addition a permanent glow lamp fitted on the switch, which provides an individual supervisory lamp for each first selector.

Section 37

TWO-WIRE REPEATER CIRCUIT FROM AUTOMATIC TO C.B. MANUAL OFFICE

The circuits (Fig. 74) are numbered in the order of operation as follows :—

1. When a calling line is extended to a repeater R′ energises.
2. Guard relay R2 energises.
3. Earth on release trunk to hold preceding switches.
4. R4 and R4′ energise to signal the distant office.



* When required to hold caller until manual operator withdraws plug.

Contacts on F to close first.
" " " " last.

If Subs. loop more than 600^ω replace battery on line relay by earth, and earth on lamp by battery.

FIG. 74.—TWO-WIRE REPEATER IN AUTOMATIC TO C.B. TRUNK (A. T. M. Co.).

5. Ring-back tone signal to caller.
6. Calling lamp at manual office glows.
7. Answering plug inserted by operator and R7 energises. Circuit 4 opened and R4′ de-energises and L6 ceases to glow.
8. R8 energises over the positive wire to manual office.
9. Battery reversing relay R9 energises.
10. R′ connections reversed to calling line.

Circuits 4 and 5 opened.

The operator rings the called party and the circuit is completed for conversation. Current for caller's microphone from R′. The called party's talking current is from the cord circuit.

Release (with earth on release trunk at relay R9). When the caller's receiver is replaced, R′ de-energises, then R2, the latter opening circuit 3, to the release trunk. Circuit 8 is also opened and R8 de-energises. Circuit 9 is opened and R9 de-energises slowly.

11. Meantime R11 energises and puts earth on the release trunk at 3′ before R9 has cut earth off. The repeater and preceding switches are therefore held operated until the plug is withdrawn at the manual office.

Alternatively, earth may not be connected to the release trunk at R9, then, when the caller clears, R′ then R2 will de-energise, as before. Circuit 3 is opened and the preceding switches de-energise. R8 and R9 de-energise. Circuit 11 is completed and R11 replaces the earth on the release trunk at 3′, to make the repeater busy until the operator clears.

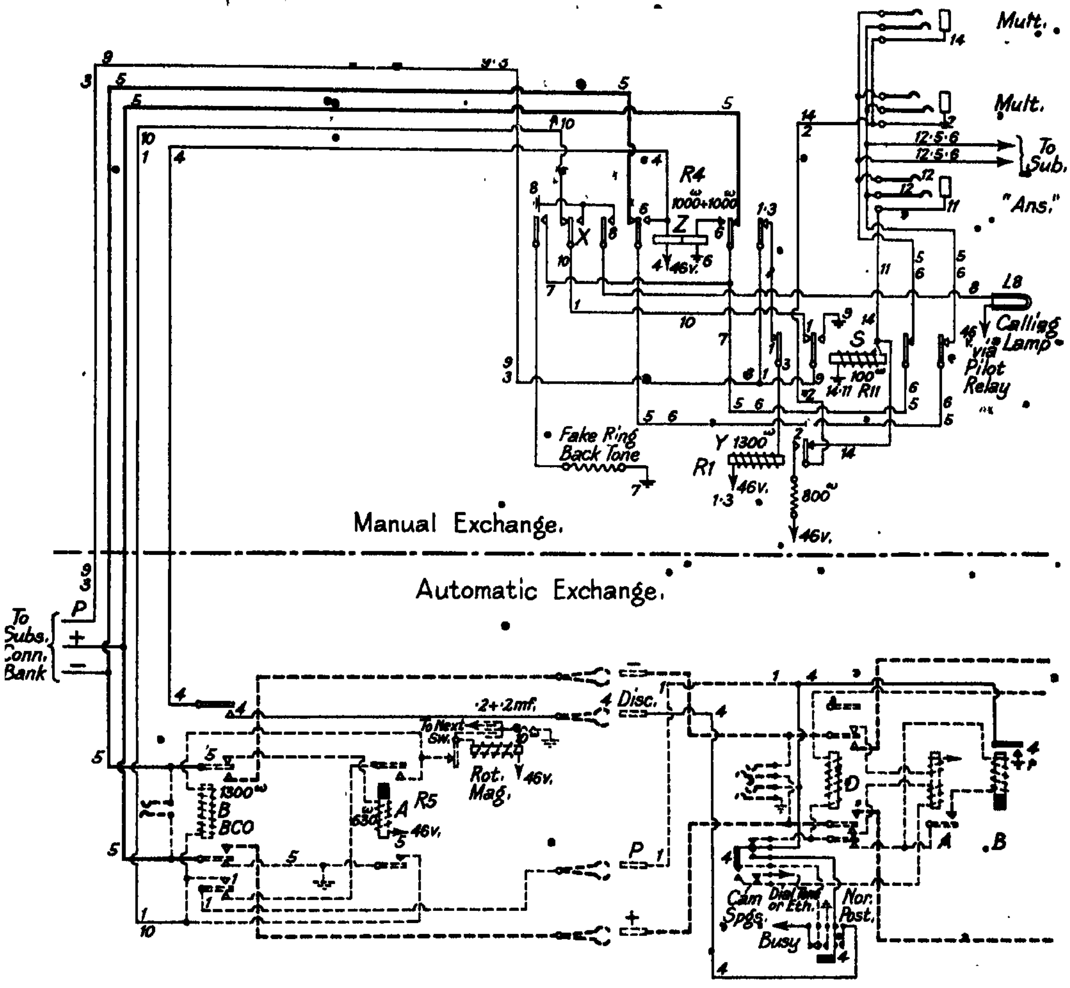
12. R2 or R11 closes the series contacts for the chain relay circuit during the whole time the repeater is in use. When the chain relay contacts on all the repeaters in the group are closed (all repeaters busy) an indication is given to the exchange attendant.

Section 38

MANUAL WORKING IN CONNECTION WITH P.A.X. INSTALLATIONS.

A. T. M. CO. (Figs. 75 and 75a).

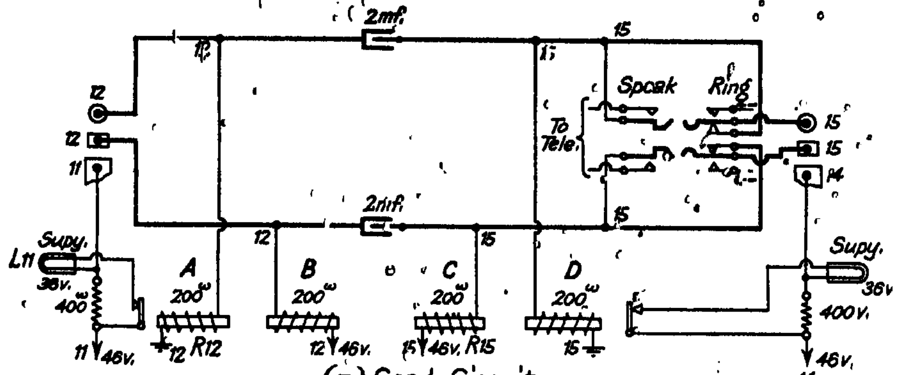
The subscribers' lines are connected to jacks and relays before being extended to the



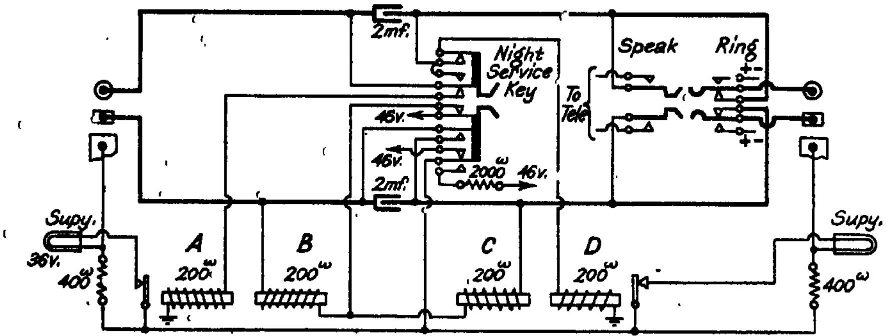
Rotary Preselector (Line Switch) Circuit. Portion of Group Selector.

FIG. 75.—ATTENDANT'S SERVICE ON P.A.X., USING ROTARY LINE SERVICE (INDIVIDUAL MANUAL CALLING APPARATUS) (A. T. M. Co.).

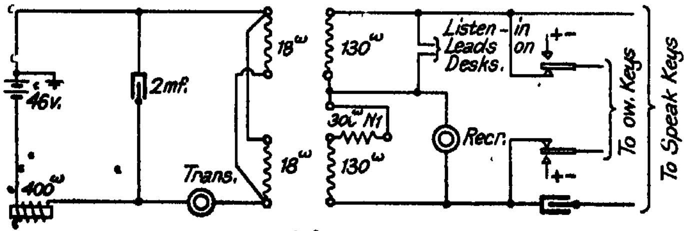
rotary line switches. This arrangement enables the automatic subscribers to call a manual operator for outgoing calls, and the manual operator can call any of the automatic lines for incoming service.



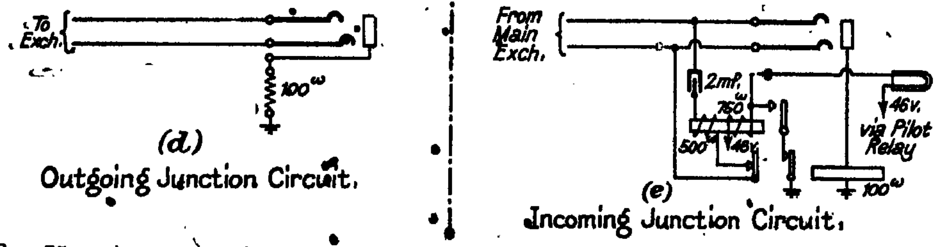
(a) Cord Circuit.



(b) Night Service Cord Circuit.



(c) Operator's Telephone Circuit.



(d) Outgoing Junction Circuit.

(e) Incoming Junction Circuit.

FIG. 75A.—ADDITIONAL CIRCUITS TO GIVE ATTENDANT'S SERVICE ON P.A.X., USING ROTARY LINE SWITCH (A. T. M. Co.).

When 0 is dialled a line lamp glows before the operator, the automatic apparatus is released, and the operator extends the call by the usual cord circuit (Fig. 75A).

When internal automatic connections are completed, protective conditions have to be set up at the manual equipment to prevent interference. Similarly, when a manual connection is completed, conditions in the automatic apparatus are set up to prevent other automatic connections.

The important circuits (Fig. 75) are numbered as follows :—

1. The earth placed on the release trunk, by the calling selector, causes R′(Y) at manual equipment to energise.

2. Busy potential is placed on the multiple jacks.

3. Earth is connected to the called party's private bank contact.

R′(Y) energises to busy the line, as before described.

When 0 is dialled to call the operator, the wipers step-up to the tenth level. As all the private contacts in this level are permanently earthed, the wipers will automatically rotate to the eleventh step, where the following circuit is closed through the normal post springs on the eleventh step cam springs.

4. R4(Z) energises.

5. The subscriber's loop is disconnected from the automatic switches.

6. The windings of R4 are connected across the subscriber's loop.

The automatic switches return to normal.

7. Ring-back tone is placed on the subscriber's line.

8. Calling lamp L8 glows.

9. Busy earth on private bank contacts, to protect the connection against other callers.

10. Circuit to caller's BSO relay opened, so that circuit 4 of the release trunk is opened. This earth would otherwise busy the trunk on which the preselector wiper rests.

While the subscriber is on the line, R4 is maintained energised, and lamp L8 continues to glow. The caller can free the connection at any time before the operator answers.

11. Answering plug inserted and busy test placed on multiple. R11(S) energises.

12. Supervisory relay R12(A) energises over the loop. Circuit of L11 opened.

13 (over circuit 9). R11 earths private connector bank contacts, to busy the line to other callers ; keeps circuit 10 open ; opens circuit 6 so that R4(Z) de-energises ; opens circuit 8 so that L8 ceases to glow ; opens circuit 7 to cut off tone ; restores the caller's preselector. The operator extends the line as required.

When the receiver is replaced, R12(A) de-energises and L11 glows.

The operator calling an automatic subscriber.—If the line is idle the plug is inserted in the multiple jack and the ringing key depressed.

14. Busy circuit. R11(S) energises to cut the subscriber's line from the automatic apparatus. Busy circuit 13 completed to private bank. Circuit 1 opened so that R′(Y) cannot energise.

If the line is busy she will still insert the plug and offer the call. If engaged on an automatic connection she will ask that the receiver be replaced, to restore the automatic apparatus. When circuit 3 is opened R′(Y) will de-energise. R11(S) is now in circuit.

14. R11 energises over the sleeve of the plug. The subscriber's line is disconnected from the automatic apparatus. The subscriber is recalled by the ringing key.

If the party wanted is engaged in another out-service call, he may accept that now offered.

He is again asked to replace the receiver, while the operator asks the party controlling the existing call to disconnect it. The subscriber is then recalled, and switched through.

Night Service.—A certain number of cords are modified as shown in Fig. 75A. A night-service key is provided which, when operated, cuts off the supervisory apparatus, and short-circuits the condensers in the talking circuit, thus providing a clean metallic circuit to the main office.

The sleeve battery is taken through a 2000-ohm resistance when the night key is operated, in order to operate the subscriber's C.O. relay with the minimum current. This relay is operated to place busy earth on the subscriber's connector private bank contacts.

Section 39

SPECIAL SERVICES FOR P.A.X. AND B.A.X. AUTOMATIC INSTALLATIONS

The equipment for special services is not provided as part of an installation unless so specified; all line-switch units, however, are wired so that any of the special services described hereafter can be readily fitted.

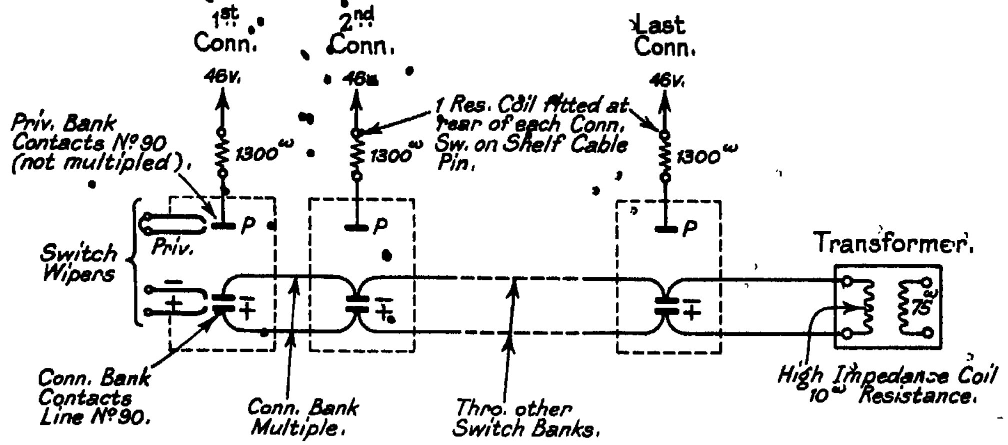
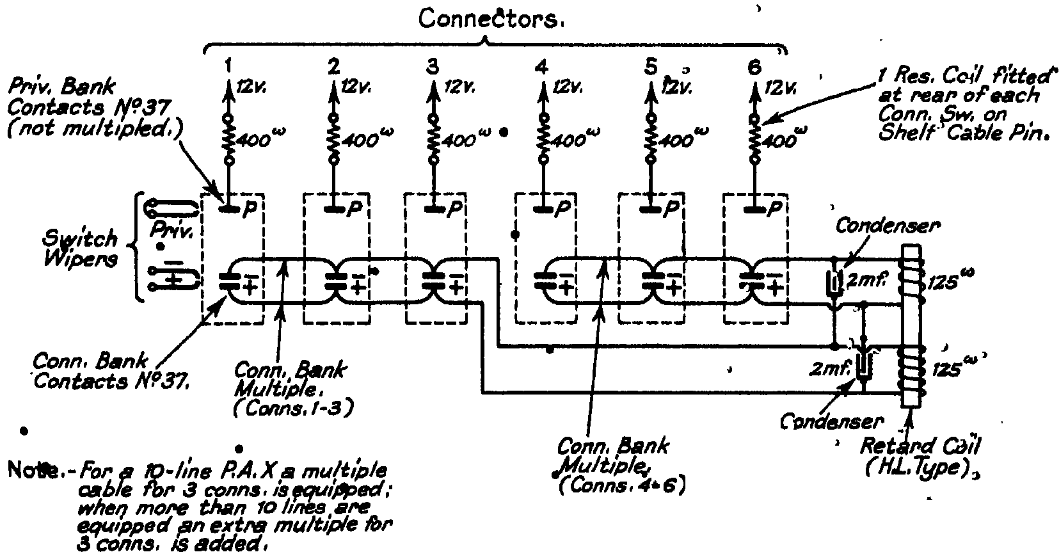

1st Conn.
2nd Conn.
Last Conn.
46v.
46v.
46v.
Priv. Bank Contacts Nº 90 (not multipled).
1300ω
1300ω
1300ω
1 Res. Coil fitted at rear of each Conn. Sw. on Shelf Cable Pin.
P
P
P
Switch Wipers
Priv.
Transformer.
75ω
Conn. Bank Contacts Line Nº 90.
Conn. Bank Multiple.
Thro. other Switch Banks.
High Impedance Coil 10ω Resistance.

FIG. 76.—CONFERENCE FOR STANDARD 46-VOLT P.A.X. EQUIPMENT (A. T. M. Co.).


Connectors.
1
2
3
4
5
6
12v.
12v.
12v.
12v.
12v.
12v.
400ω
400ω
400ω
400ω
400ω
400ω
Priv. Bank Contacts Nº 37 (not multipled.)
1 Res. Coil fitted at rear of each Conn. Sw. on Shelf Cable Pin.
P
P
P
P
P
P
Switch Wipers
Priv.
Condenser
2mf.
125ω
2mf.
125ω
Condenser
Retard Coil (H.L. Type).
Conn. Bank Contacts Nº 37.
Conn. Bank Multiple. (Conns. 1-3)
Conn. Bank Multiple. (Conns. 4-6)

Note.—*For a 10-line P.A.X a multiple cable for 3 conns. is equipped; when more than 10 lines are equipped an extra multiple for 3 conns. is added.*

FIG. 76A.—CONFERENCE FOR 12-VOLT 25-LINE P.A.X. (A. T. M. Co.).

Conference Service (Fig. 76).—To facilitate the close supervision required in a large organisation, the conference service has been developed. This service enables several executive or departmental heads to obtain connection with a conference circuit so that they can confer and discuss matters without leaving their desks.

This service is designated by a number, for instance, 90. The corresponding line switch is removed and replaced by an impedance coil bridged across the line contacts. In addition, the private contact multiple of No. 90 is opened between each connector bank, and a resistance coil is bridged from each private contact to negative battery. The various executive officers can be called and asked to dial the conference number.

A Modified Private Switchboard Conference Circuit, A. T. M. Co. (Fig. 77).—A conference circuit is multipled over a level, say the tenth, of a number of selectors. A circuit-changing relay is fitted between each line to be connected to the conference circuit and the rotary line switch.

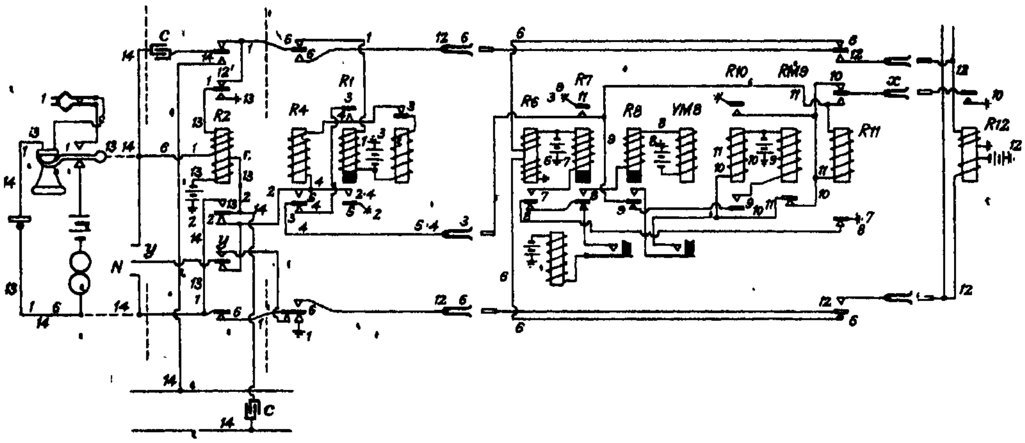


FIG. 77.—CONFERENCE CIRCUIT IN PRIVATE EXCHANGE (A. T. M. CO.).

Ordinary connections are made over the line switch and connectors. A conference connection utilises the selector to build up the connection, but when the special relay is energised the selector and line switch are released.

The circuits are as follows :—

1. Line relay R′ energises. Circuit is through R2, but this relay is energised only when current is through both windings in the same direction.

2. Current through second winding of R2 but opposite in direction.

R′ initiates the operation of the rotary line switch, in known manner, to extend the caller to a selector. The tenth level is assumed to be a conference circuit.

When the subscriber dials 0 R6 responds, and the wipers are stepped-up, in known manner, then rotated automatically to the first set of contacts.

As there may be a number of calls at a given time the line may test busy, and the wipers step until an idle unearthed line is found

11. R11 energises.

12. R12 energises over the caller's loop. The current in the upper winding of R2 is now reversed and the relay energises.

13. R2 energises over the calling line.

14. The calling line is extended to the conference circuit and the line switch and selector released.

Circuit 12 is open at 12′ of special relay and R12 de-energises. Circuit 10 is open to release the selector.

The private normal terminal is earthed over *y*.

Section 40

CODE-CALL SERVICE

By this means any officer can be reached for telephone service so long as he is within hearing of a call bell of the installation, although he may be away from his office.

If a called party fails to answer his telephone, the caller replaces his receiver, again removes it, and dials the code number, 70, followed by the individual code of the party desired. This code is sounded on bells, buzzers, horns, or other signalling devices throughout the establishment. A person hearing his code proceeds to the nearest telephone and dials the answering number, 79, to be at once connected to the caller.

Two types of equipment are available, one for twenty-two individual code numbers and the other for one hundred.

These special equipments consist of code-selecting switches, enclosed in cabinets arranged for mounting on a wall near the switchboard, together with the loud signalling devices which are placed throughout the establishment where they will be most effective.

Code-Call System, using Connector Banks and Commercial Power (Fig. 78).—The code consists of 22 groups of long and short signals, thus allowing 22 subscribers to have code-call facilities. It is possible for all the lines on the switchboard to signal any code on the code-call signals, and so attract the attention of any of the subscribers who have code-call facilities. The called party, on hearing his code signalled, is able to answer the call from any telephone which may be handy. Specially wired connectors are used with this system in order to work in conjunction with the code-call cabinet.

The circuits of Fig. 78 are numbered in the order of operation as follows :—

A caller having failed to obtain a response in the usual way replaces the receiver to clear, then again lifts it and dials the special code-calling number, to set the wipers of the connector on that particular number. The code-call cam springs operate (see Fig. 72 of connector), disconnect the ringing circuit, and close the impulsing circuit to the positive wiper.

1. R′(D) energises over earth on P2.

The first digit of the code number is now dialled over the impulse circuit.

2. Impulse circuit, earth at connector line relay A, over code cam springs and positive wiper. R2(E) energises for the duration of the impulses, M2 steps the wipers to the called number.

The code numbers of the subscribers are divided into three groups :—

a. Digits 1 to 9.—It is necessary to dial only one digit in order to obtain any one of this group.

b. Digits 01 to 09.—It is necessary to dial two digits. The first digit 0 causes the wipers of the code-selector group switch to rest upon the tenth contact in the banks. As these are disconnected, they provide a convenient resting-place for the wipers until the next digit is dialled. The caller now dials the last digit and the wipers are stepped on to the desired number.

Digits 001 to 009.—It is necessary to dial three digits. The first two digits 00 cause the wipers to step on to the twentieth contact in the banks. The caller now dials the last digit and the wipers step to the desired number.

After the caller has dialled the final digit the fourth code-selector wiper will complete the following circuit :—

3. R3(C) energises. Circuit 2 is opened so that M2(J) will not again be energised in error.

4. R4(A) energises in parallel with R3.

5. Rotary magnet M5(K) energises. The first and second wipers of the code interrupter switch are moved round one step. The interrupter springs break circuit 4 and R4(A) de-energises and opens circuit 5. Rot. magnet M5 de-energises, again closes circuit 4, and R4 re-energises. This cycle of operations continues, and the wipers are stepped round the bank until either the called party replies or the caller replaces the receiver. The copper mass and the micrometer adjustment of R4 make it possible to adjust the interruptions to the desired speed.

6. Excessive sparking at the contacts of R4 is prevented.

7. As the first wiper of the code interrupter switch rotates over the contacts of the bank, R7(F) energises over contacts 2, 5, 8 and 11 of the interrupter bank. Thus is provided part of the necessary combination for code signalling, the other part of the combination being provided by the bank contacts, traversed by the wipers, and to relay R7(F) over the first, second, or third wipers of the code selector. The operations of R7 close the signalling circuit for a series of short and long periods, in accordance with the particular code called.

8. Circuit to all the code bells.

The called party answers.—The official, on hearing his code, proceeds to the nearest telephone and dials the number allocated to answering, and is thus connected to the caller. This is attained by the lines of the two numbers allotted to code call being bridged on the connector bank multiple. Therefore both the calling and the called connectors are joined in the circuit, to furnish a talking circuit between the two parties.

It will be noticed that the connector banks are reversed in the diagram, the positive of the answering number being connected to the negative of the calling number, and the like. This is necessary to trip ringing on both connectors when the called party answers.

The code selector and interrupter return to normal.

9. R9(B) energises and opens circuits 1 and 2 and places dead earth on the P2 wiper (circuit 1).

10 (partly over 7). Circuit of R′ is opened, but the relay is maintained over the code interrupter until the wipers return to normal. When normal is reached, earth is cut and R′ de-energises.

11 (partly over 7). Rotary magnet M2(J) energises, and the code selector is stepped to normal.

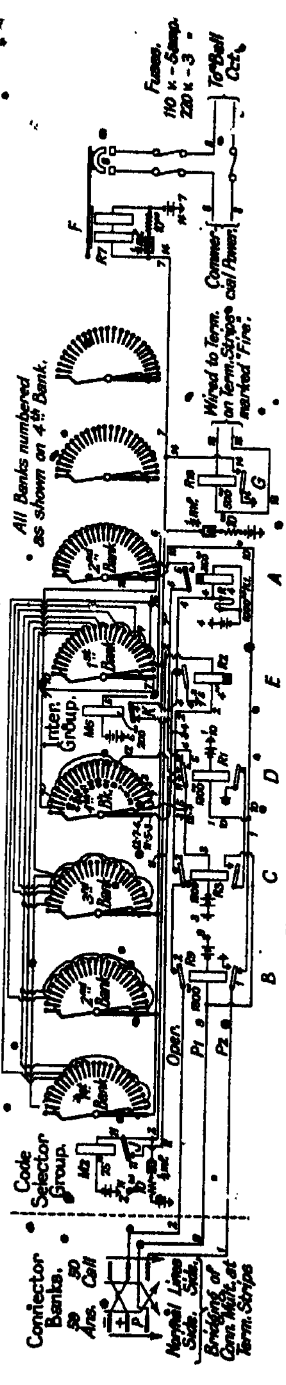

Fuses. 110 v.–5 amp. 220 v.–3
To Bell Cct.
F
R7
Connect'n cal Power
Wired to Term. on Term. Strips marked "Fire."
All Banks numbered as shown on 4th Bank.
G
A
E
Inter. Group.
D
C
B
Open.
P1
P2
Code Selector Group.
Connector Banks. 80 Call 90 Ans.
Normal Lines Side.
Bridging of Conn. Mult. at Term. Strips

FIG. 78.—CODE-CALL SELECTOR (A. T. M. Co.).

12 (partly over 17). Earth on the stopping contacts 10, 20, to rotate the wipers past these contacts on the return to normal.

After the code selector and code interrupter have returned to normal, R0(B) is held by the private wiper of the caller's connector until the called switch restores. Thus earth is maintained on the private bank of the calling number to keep the code-call cabinet busy, should the caller first replace the receiver.

Description of Typical Code Combination.—The operation of R7(F) closes the circuit for the ringing of the code bells. In order to obtain the short and long rings, R7 is energised for varying periods, which are determined by the circuit combinations set up on the code selector and code interrupter switches.

7. Earth is placed on the first wiper of the code interrupter by the fourth wiper of the code selector.

When the full complement of impulses has been dialled into the code-call circuit, the wipers of the code interrupter rotate continuously. Thus earth is placed on R7 by special circuit combinations over the first bank contacts of the code interrupter, or, first, second, and third bank contacts and wipers of the code selector.

A typical code combination is given below :—

Number 5 called. Code = 1 long ring and 1 short ring.

1.
2. Earth placed on relay R7 direct by wiper.
3.}
4.} ,, ,, ,, *via* No. 1 code-selector wiper.
5. ,, ,, ,, direct by wiper.
6.}
7.} ,, ,, ,, *via* No. 2 code-selector wiper.
8. ,, ,, ,, direct by wiper.
9.}
10.} Silent period between ringing period.
11. Earth placed on relay R7 direct by wiper.
12.
13.
14.
15.
16.
17.
18.}
19.}
20.}
21.}
22.} Not used.
23.}
24.}
25.}

From the foregoing combination the following are to be noted :—

(1) The period of the *long ring* is that taken by the wipers to rotate over seven contacts.

(2) The period of the *short ring* is that taken by the wipers to rotate over one contact.

(3) The spacing or *silent period* between the associated rings is that taken by the wipers to rotate over two contacts.

Code Signals.

The following is the list of code numbers with associated signal code :—

Code No.	*Signal Code.*
1	1 long.
2	2 long.
3	4 short.
4	5 short.
5	1 long and 1 short.
6	1 short and 1 long.
7	1 long and 2 short.
8	1 long and 3 short.
9	1 long, 1 short, and 1 long.
01	2 short and 1 long.
02	3 short and 1 long.
03	1 short, 1 long, and 1 short.
04	1 short, 1 long, and 2 short.
05	2 short, 1 long, and 1 short.
06	1 short and 2 long.
07	2 long and 1 short.
08	1 long and 4 short.
09	4 short and 1 long.
001	3 short, 1 long, and 1 short.
002	2 short, 1 long, and 2 short.
003	1 short, 1 long, and 3 short.
004	6 short.

Fire-Alarm Circuit.—A special number is allocated on the automatic exchange for fire alarm.

13. When this number is called, relay R13(G) in the code-call circuit is energised *via* the calling connector.

14. Relay R7(F) energises and rings the code bells continuously.

Section 41

CODE-CALL SYSTEM USING SELECTOR LEVELS AND COMMERCIAL POWER, A. T. M. CO. (Fig. 79)

The code, like the former, consists of 22 groups of long and short signals, and the results obtained are very similar to those in the system just described.

In this a special selector level is allotted to the code-call system for calling purposes, and one number on the exchange is reserved for answering purposes, no line switch being fitted on this number.

To call.—A caller having obtained no response in the usual way, dials the number associated with the selector level for code calling.

1. R′(E) energises over the caller's loop.

2. R2(D) energises.

3. Release trunk earthed, to hold the preceding switches.

4. R4(C) energises to open the circuit for busying the code-call circuit, until all the apparatus has restored to normal.

5. R5(B) energises to open the bank connections on contacts 10 and 20 of the fourth code selector bank.

The circuit is now prepared for dialling.

6. R′ de-energising intermittently closes this circuit, R6(H) energises for the duration of the impulses, and RM6 steps the wipers round to the called number. R6 keeps earth off the fourth code-selector wiper during its rotation.

The code numbers of the subscribers are divided into three groups in the manner described in the previous arrangement.

7. R6 having de-energised, R7(A) energises over the fourth code wiper.

8 (partly over 7). R8(G) energises in parallel with R7. Impulse circuit 6 is opened to prevent false impulsing.

9. Code interrupter rotary magnet RM9 energises, and moves the wipers round one step. The interrupter springs open circuit 7, and R7 de-energises. Circuit 9 is then opened, and RM9 de-energises. Circuit 7 is again completed, and R7 re-energises. This cycle of operations continues, and the wipers are stepped round until either the called party answers or the caller clears.

The copper mass and the micrometer adjustment of R7 make it possible to adjust the interruptions to the desired speed.

10. As the first wiper of the code interrupter rotates over the bank contacts relay R10(M) energises over contacts 2, 5, 8 and 11.

Relay R10(M) operating over these contacts, provides part of the necessary combination for the code signalling, the other part of the combination being provided by the bank traversed by the wipers, and to relay F(R12), over the first, second, or third wipers of the code selector. The operations of relay R10(M) close the signalling circuit for a series of short and long periods, in accordance with the particular code called.

11. The special code signal is given out on all the code bells.

The called party answers.—The called party, on hearing his code, proceeds to the nearest telephone and dials the answering number, and is thus connected to the caller. This result is obtained by the line of the number allocated to the code call being connected over a 2-mfd. condenser in each wire, to the lines on the selector level trunk to code call.

The called party's connector-wiper control relay is energised over the 46-volt battery, in series with a 1000-ohm resistance on the private bank contact of the code call answering number. Therefore, the connector places ringing current on the line.

12. The ringing current energises R12(F) of the code-call circuit.

The ring cut-off relay in the connector is also tripped, and the talking circuit is completed.

13. R12 locking circuit. Impulse circuit 6 is opened. Circuit 12 is opened to cut-off R12 200-ohm winding. Circuit 5 is open to cut off R5.

14. Talking circuit. The caller gets battery from R′, the called party gets battery over his connector.

Code selector and code interrupter return to normal.

15 (partly over 7). When circuit 5 was opened, R5 did not de-energise, but was maintained over the second bank and wiper of the code interrupter, until the wipers return to normal. This switch continues to rotate until normal is reached when R5 restores.

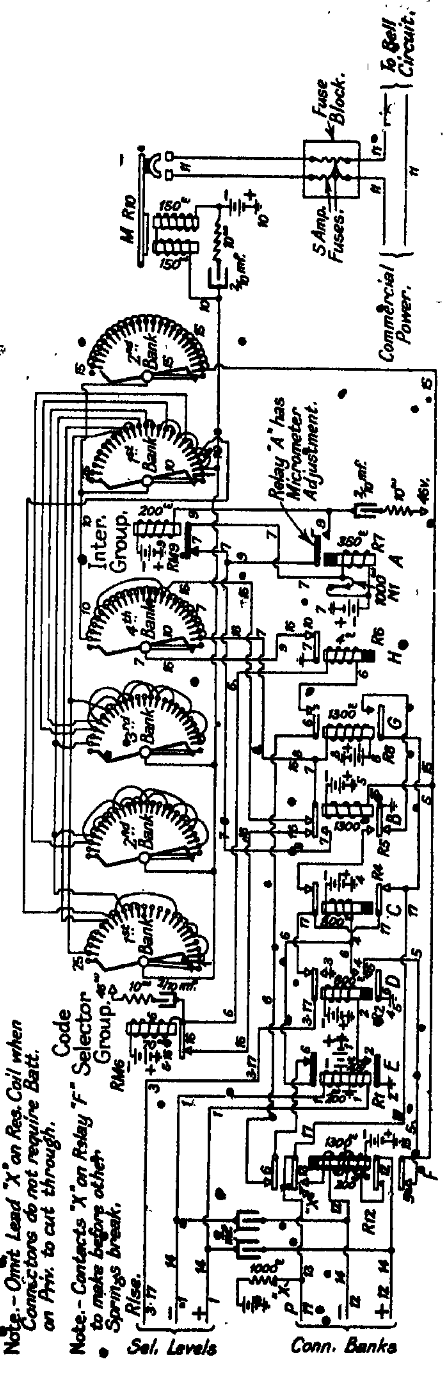
16. RM6 energises and steps the wipers to normal.

16′. Circuit over 10 and 20 contacts to rotate wipers past these.

Caller replaces receiver first.—Relays R′(E), R2(D), and R4(C) de-energise, but earth is maintained on the release trunk.

17. Code-call cabinet is kept busy until the called party has cleared.

Typical Code-Call Combinations.—This is exactly as described for the previous diagram, R10(M) taking the place of R7(F).



Note.—Omit Lead "X" on Res. Coil when Connectors do not require Batt. on Priv. to cut through.

Note.—Contacts "X" on Relay "F" to make before other Springs break.

FIG. 79.—CODE-CALL SYSTEM (A. T. M. Co.). SELECTOR LEVELS.

Section 42

CODE SIGNALS FOR OFFICIALS IN WORKS AND THE LIKE

Another circuit is shown in Fig. 80, which amplifies certain features.

This code-ringing equipment is connected to a particular set of terminals on the connectors. In the circuit to be described, No. 70 has been chosen. Calling No. 70 connects up the ringing equipment, and further series of impulses are then called to sound the code. The multiple of terminals 70 and the multiple of the answering number terminals, say, 75, are connected together. The code-ringing equipment comprises a rotary switch with four wipers, *g*, *h*, *j*, *k*, and a rotary ringing switch with two wipers *m*, *n*.

The operation of the arrangement is as follows, first for an ordinary call. In the diagram only two connectors are shown, each of which would be reached by two subscribers' lines over rotary or other line switches and selectors, if the office requires such.

1. When the receiver has been lifted to call and the line has been extended to the connector R′ energises.

2. The guard relay R2 energises.

First series of impulses are dialled.

3. R3 energises for the duration of the impulses, and VM3 steps the wipers up to the associated level. At the first step contacts ON are closed.

4. Path for impulses after the first. After impulses R3 de-energises.

Second set of impulses dialled.

5. R5 energises for the duration of the impulses, and RM5 steps the wipers round to the called line terminals.

6. Alternative path for impulses should R7 be energised momentarily by earth on wiper *c* when passing over earthed test terminals.

Busy test and busy signal.

7. R5 completes a circuit for wiper *c* to winding of R7 (combined test and answering bridge relay). If the called line is busy, the test terminal is earthed and R7 is energised. Circuit 5 is opened to RM5. Circuit 10 is opened to R10.

8. Busy tone to calling line.

9. R7 locking circuit when R5 de-energises.

When the caller replaces the receiver, circuit 9 is opened to release the connection.

Supply and control of ringing current for ordinary calls.

10. If the called line is idle, R10 energises (after R5 de-energises).

11. R10 locking circuit.

12. Earth on wipers to busy the called line.

13. Ringing circuit to called line. When the called party answers, R13 energises to cut off ringing and join line through. Battery B is in series with battery at RM5 to ensure R13 energising.

14. Ringing tone induced in upper winding of R13.

15. Current to the called microphone through R7.

Operation of the connector for a code call (see lower part of Fig. 80).

A cam is fitted on the connector-shaft, arranged to switch a centre spring from a contact to another spring. This disconnects the ringing generator RG and prepares a path for the necessary additional impulses.

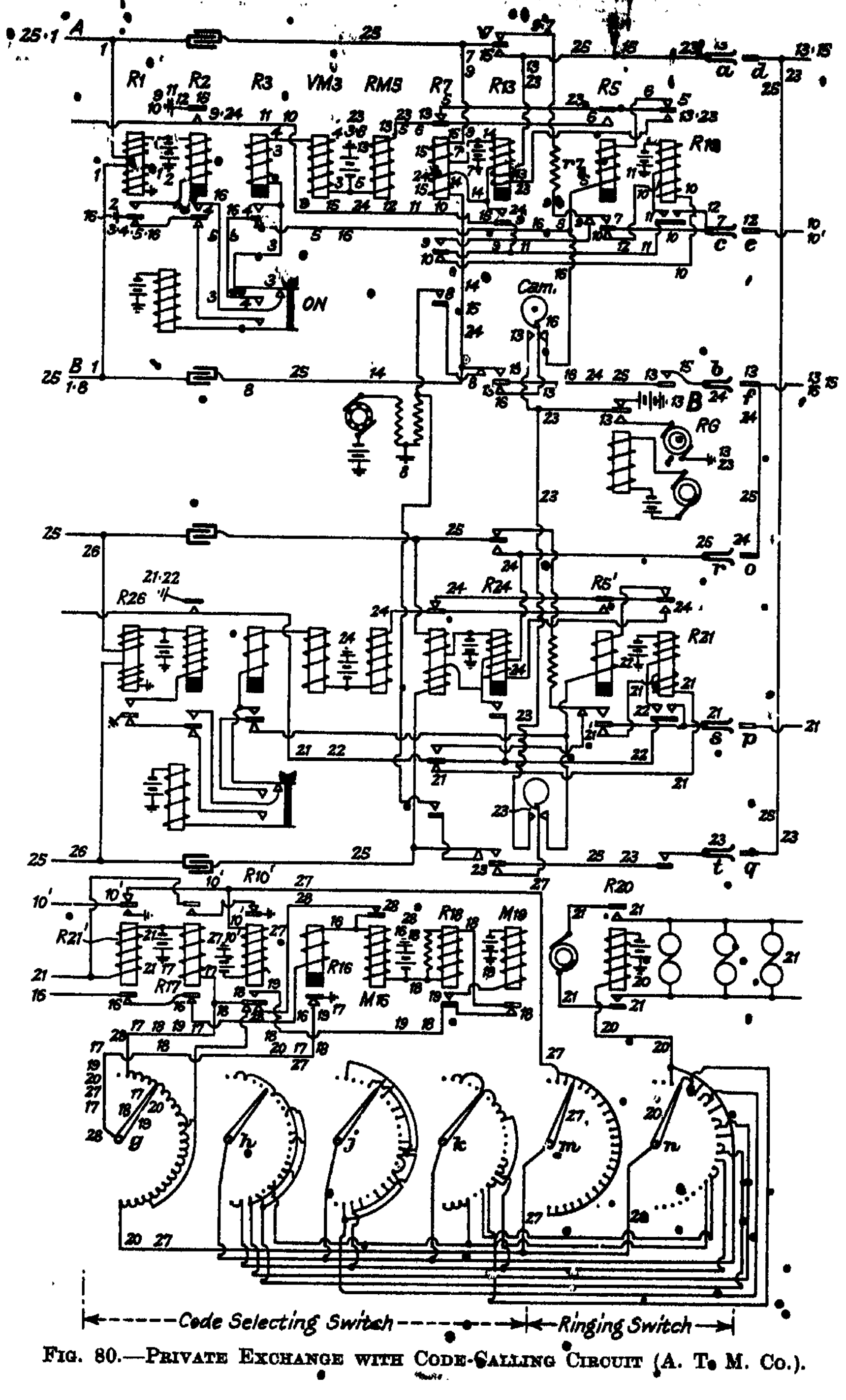


FIG. 80.—PRIVATE EXCHANGE WITH CODE-CALLING CIRCUIT (A. T. M. Co.).

The caller dials the special number and the wipers are moved to the terminals *d, e, f* of No. 70. If the equipment is busy, tone is given to caller—all as before described.

If the equipment is idle, R10 energises in series with R10′ (lower part of Fig. 80).

The caller then dials the code (one or two digits) of the party wanted.

16. Impulse circuit to the ringing equipment. R16 energises for the duration of the impulses and M16 rotates the wipers *g, h, j, k*.

The eleventh and twenty-first contacts engaged by wiper *g* are not multipled to the other contacts, to permit the wiper to move 10 or 20 steps without starting the ringing switch. When the impulses cease R16 de-energises.

17. R17 energises and opens circuit 16.

18. R18 energises and closes circuit 19.

19. M19 energises and opens circuit 18 and R18 de-energises. The vibratory movement thus set up causes the wipers to advance step by step in known manner, so long as the earth is maintained on circuits 18 and 19.

20. R20 energises. The contacts engaged by the wiper *n* are so connected to the wipers *h, j, k* and their contacts that, during the rotation of the wiper *n*, R20 is energised for long and short periods according to the setting of the wipers *g, h, j, k*.

21. Ringing circuit of code bell.

The code ring is repeated during each rotation of the wiper *n*.

When the called party hears his distinctive call he goes to the nearest telephone and dials a special answering number, in this case 79, whereby a connector, say X, operates in the manner before described to move its wipers to the special terminals *o, p, q* (which are connected to the terminals *d, e, f*) of the special call No. 70.

21. When the slow relay R5 de-energises at the end of the rotation, R21 and R21 energise.

22. R21 locking circuit.

23. R13 energises and holds over its upper winding, and extends the line to the wipers *a* and *b*.

24. R24 energises and acts in a manner similar to R13 to extend the line to the wipers *r, t*.

25. Talking circuit. Microphone current fed through R′ and R26.

Disconnection and restoration of the code-ringing equipment.

When R21′ energises, circuit 10′ is opened by R10′. Circuit 16 is opened and M1 is cut off.

27. R10′ is held energised over wiper *k* until the ringing switch reaches its norma position. The wiper *m* then engages a dead contact and R10′ de-energises.

28. Restoring circuit of M16, which is opened when the wiper *g* reaches normal.

The connection is released in known manner.

Section 45

MISCELLANEOUS SERVICES

Watchman's Service (Fig. 81).—This service is of great benefit in small as well as in large establishments, as it enables the department head responsible for the watchmen to have a permanent record of their movements.

This service enables the watchmen to report, on their rounds, by momentarily lifting the receivers of specially-designated telephones, which action on the part of the watchmen, causes a magnet associated with that particular line, and located in a recording-clock, to operate and record the time on a revolving chart. The charts are a permanent record of the movements of all the watchmen during the time that they are on duty.

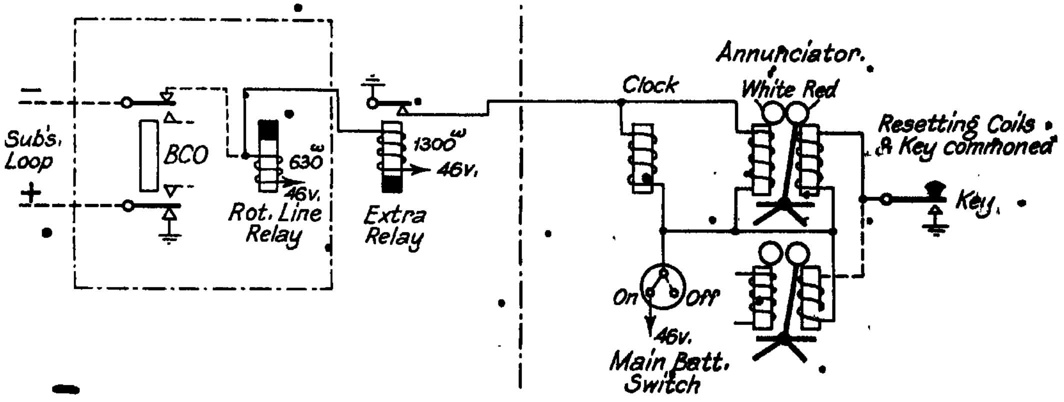


FIG. 81.—WATCHMAN'S SERVICE. ROTARY LINE SWITCH CIRCUIT (A. T. M. CO.)

For large establishments, where the services of a head watchman are required, the reports, in addition to being recorded on the chart in the clock, may be made visible on an annunciator located in his office. An annunciator cabinet holds annunciators (indicators) which remain operated, and these are restored to normal by a push button. Provision can be made whereby the head watchman is able to cut in on any line on the system, whether busy or not, by means of special connectors installed on the line-switch board.

Fire-Alarm Service (Fig. 82).—This service is a combination of the conference code call and watchman's service.

When a person wishes to report a fire he dials the designated number, such as 99, which at once sounds the general fire-alarm signal. This is a notice that all unimportant telephoning must cease at once, so as to release the switches for certain officials, whose duty it is to come in on the alarm number, and listen to the man reporting the fire. The head watchman also comes on this line by means of the special connector. The executive officers hear the report regarding the fire and in conference decide what steps are to be taken and, if general notice is to be given as to the location of the fire, the head watchman will dial the proper code number on the code-calling equipment (see end of Section 40).

Executive Priority (Interception) Service.—This service allows certain executive officers to cut in on any line which may be busy, and either listen or speak to the parties engaged. If it is desired, a tone can be placed upon the line when the officer cuts in, to notify to the parties engaged in conversation that such officer desires to speak to either or both of them.

For this service, in a 100-line system, an additional special connector is provided for each officer, and a key to switch his telephone from his regular line to this special line.

In a system using selectors, special selectors must be provided for each officer's line, together with a key for switching his telephone to the special selector; and one or more special connectors installed on each line-switch unit, according to the amount of traffic required for this service.

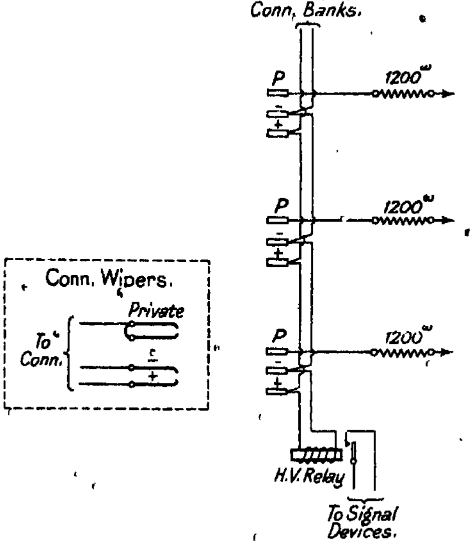


FIG. 82.—FIRE AND EMERGENCY ALARM FOR P.A.X.'S, ROTARY, OR KEITH LINE SWITCHES (A. T. M. Co.).

Secretary Service (Fig. 83).—If an executive officer, such as the manager of a company, prefers that his secretary should handle the incoming and outgoing calls for him, this arrangement can be made, as shown in Fig. 83, by the use of an arrangement of buzzers between their offices.

When a call comes in, the bell at the secretary's telephone rings. He answers, and if it is one to which the manager should reply, he presses a button which causes the manager's buzzer to sound. The manager then answers, and the secretary replaces his receiver. If the manager desires positive secrecy, he presses a cut-out key which removes the secretary's telephone from the line.

When the manager desires the secretary to make a call for him, he presses a key to operate the secretary's buzzer, the latter answers on his telephone and receives instructions. The manager replaces his receiver and the secretary puts the call through, calling by buzzer when the call matures.

number which other officials may call, and obtain direct access to the manager. This is attained by connecting the bank contacts of this separate number to the manager's line, transposing this connection, and installing an additional bell in the manager's office. Because of the transposition of the lines and the connection of each bell to earth, the ringing is selective. Calls on this particular number will only ring the manager's bell, and he will answer personally, because he knows the call is from one of a restricted group of officials who alone know the number. Other calls will come in and ring the secretary's bell in the usual manner.

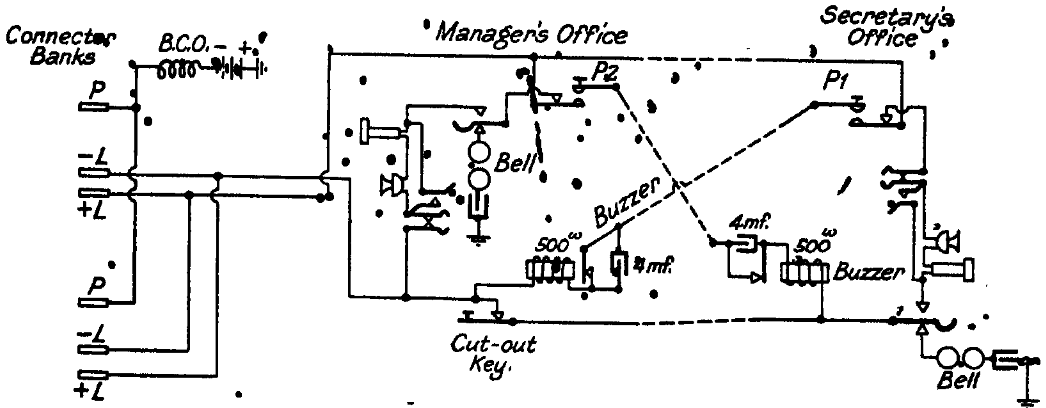


FIG. 83.—SECRETARY SERVICE CIRCUIT (A. T. M. Co.).

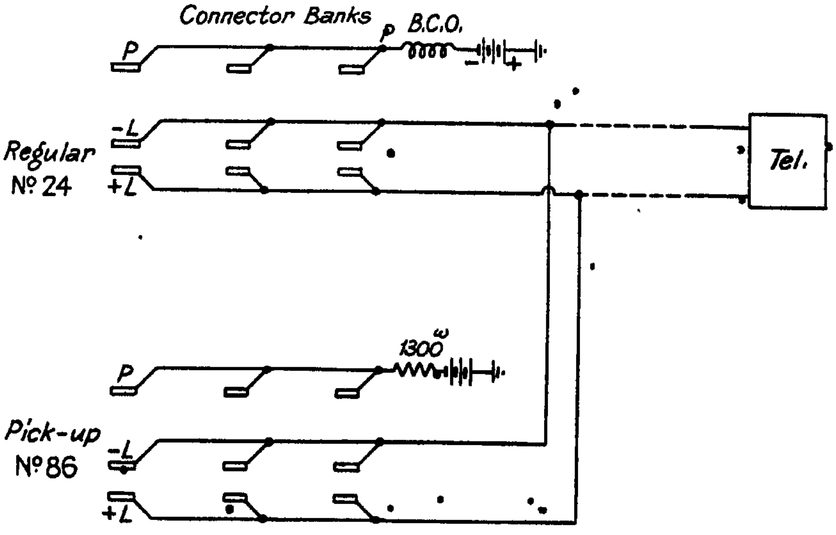


FIG. 84.—DOUBLE NUMBER PICK-UP CIRCUIT (A. T. M. Co.).

Double Number Pick-up (Fig. 84).—If an executive officer, who has no secretary, calls his office from any part of the establishment, and finds the line busy, he assumes that there is a call for him. In a manual system he would flash the operator and ask her to transfer the call to the telephone he was using. A similar result is obtained in an automatic system, as shown in Fig. 84. A special number is allocated for this service, in addition to the regular directory number. The wires from this special number are multipled with the wires of the regular number, and the private bank contact is connected through a 1200-ohm resistance coil to negative battery. The line switch of this special number is removed. The official can now call his office special pick-up number and answer the party who has called his office directory number.

This arrangement is also useful in case the call to the official's office has been answered by an assistant, who finds it expedient that the executive officer should answer the call. The secretary or assistant can call this officer by the code-call system from an adjacent telephone, and have the officer call in on his own line, from any part of the establishment, by means of this double number pick-up.

Section 44

SIEMENS EQUIPMENT FOR A 100-LINE PRIVATE EXCHANGE.

This is known as their *Autophone System No.* 2. A general view is shown in Fig. 92. The apparatus used includes a line switch, or preselector, per calling line, and a percentage of connectors according to the traffic to be carried. The preselectors and connectors are similar to those used on larger equipments, illustrated in Figs. 65 to 69, Vol. I, but having simplified circuits. The telephone instruments are also of standard pattern, with circuits as shown in Figs. 21 and 22, Vol. I. These are fitted with the dials shown in Figs. 8 and 9, Vol. I., or Fig. 125, Vol. II.

These equipments are fitted with alarm circuits, so that faults can be readily localised and remedied.

The battery is of 60 volts, and two sets of accumulators are supplied with all charging facilities.

This equipment can be used in connection with a public exchange.

Fig. 85 shows the circuits. Siemens particular circuits are also shown as key diagrams, in Fig. 86. These are numbered in the order of operation, and are as follows :—

1. When the receiver is lifted, R′ energises.

2. The magnet M2 energises and steps the wipers round to find an idle line.

3. Relays R3 and RR3 energise, when the wiper C makes contact with an idle line test terminal. The wipers then come to rest.

4. Holding circuit of R3 over its 15-ohm coil. R′ and M2 de-energise.

5. Loop 1 is extended to the connector relay R5.

6. Holding circuit of RR3.

7. R7 energises.

8. Permanent loop lamp glows.

9. R9 energises (slow to de-energise).

The tens digit is now dialled.

When the loop is opened for the first impulse, R5 de-energises.

10. R10 energises (slow to de-energise).

11. Holding circuit for RR3.

When the loop is again closed to complete the impulse, R5 re-energises.

12. The vertical magnet VM12 energises and lifts the shaft one step. The K contacts operate. Circuit 8 is open and PL lamp ceases to glow. The following impulses of the digit train act in a similar way, to lift the shaft to the desired level. Relays R9 and R10 remain energised during the impulsing. At the end of the train R5 remains energised. Circuit 10 is open and R10 de-energises. Circuit 11 is open and RR3 de-energises.

13. Holding circuit of the C wire.

14. Holding circuit of R7.

The units digit is dialled.

When the loop is first opened, R5 de-energises and closes circuit 10, and R10 energises.

15. Holding circuit of R10 and R7, when W2 contact is opened on the first rotary step. R5 re-energises at the completion of the first impulse.

16. RM16 energises, and the wipers rotate one step. Additional impulses act in a similar way, to rotate the wipers to the terminals of the desired line.

The circuit of the 900-ohm winding of R17 is open at 17′, to prevent interference, when wiper C is passing over line terminals.

At the first rotary step the W contacts are operated. At the end of the train R5 remains energised. R10 de-energises. R7 de-energises after a short interval, circuit 15 being open. Circuit 16 is open, and RM16 de-energises.

17. R17 energises over the C wiper.

18. R17 low resistance engaging circuit.

19. Ringing circuit through the bell of the called station.

20. R7 is controlled by R17 and connects to the ringing distributor. R7 now pulsates and connects ringing current intermittently to the called line, over circuit 19.

21. Each time R7 is energised ringing tone is connected to the calling line.

22. When the called subscriber answers, R22 energises over its lower winding, and opens the short-circuit on its upper winding.

23. RR3 again energises in the third conductor holding circuit over W′. Circuit 20 is open, to cut R7 from the ringing distributor.

Conversation now takes place.—Current for the calling microphone is supplied through R5, and that for the called line through R22.

If the called line is busy, R17 does not energise, as it is shunted by the 30-ohm coil of the line engaging the called party. If the called party has originated the call in which he is engaged, the C wiper will be off its normal contact, and there will be no circuit for R7, which then de-energises, as circuit 15 is open.

24. Busy signal to caller.

Release.—When the called subscriber replaces the receiver first, R22 de-energises.

25. R22 short-circuits the 30-ohm winding of R17, which de-energises. Circuit 18 is open, battery is cut off the C wire, and R3 of the called line de-energises. The called line is now free. Circuit 19 is open, to prevent interference whilst the wipers are returning to normal. Circuit 24 is completed, and the caller gets a continuous tone, as a signal to replace the receiver.

When the caller replaces the receiver, R5 de-energises, then R9.

26. The release magnet M26 energises, and steps the wipers to normal. The C wire is open at 3′, over M26, and RR3 and R3 of calling line de-energise. Contact 3′ is again closed, when the wipers are at normal and the shaft has dropped. Contact K2 is open to open circuit 26. All apparatus is then at normal.

When the caller replaces the receiver first, R5 de-energises. Circuit 9 is open and R9 de-energises. Circuits 17 and 18 are open, and R17 de-energises.

The remainder of the release operations are as before described.

Section 45

A PRIVATE SWITCHBOARD WITH A CAPACITY OF 200 LINES, SIEMENS (Figs. 87 and 88)

The lines are divided into two 100-line groups, and discriminators are introduced, to connect with one or other of the groups, according as the first digit is 2 or 3. These discriminators are inserted between the preselectors and the connectors. Another function of the discriminator is to distribute the calls over the connectors.

Each discriminator set consists of two preselectors and a set of relays, which are under the control of the caller.

All numbers, necessarily, have three figures.

Digit 1 is avoided as the first figure of a number, to prevent false calls due to inadvertent movement of the switchhook.

Test jacks are provided, in order that each switch may be tested from a test set, by means of a test plug. Similar jacks are provided on each line leaving the discriminator multiple, in order that the connectors may be tested in the same manner.

The *b* and *c* lines are reversed on these jacks, in order that the *c* line may be earthed, after the *a* and *b* lines are looped, when plugging in. The receiver of the test instrument should be removed before inserting the plug, otherwise a false impulse would be received on the switch under test.

The circuits (Figs. 87 and 88) of the discriminator are as follows :—

30. Circuit 3 of the preselector is extended to R30, which energises (made slow to de-energise).

31. Parallel circuit to R30 winding.

32. R32 energises (slow to de-energise).

33. Impulse relay R33 energises.

34. Permanent loop lamp glows.

First digit is dialled.

When the loop is opened, R33 de-energises.

35. R35 energises (slow to de-energise).

When the loop is closed to complete the impulse, R33 re-energises.

36. R36 energises.

37. New circuit for R32.

38. On the second de-energisation of R33, R38 energises.

39. Holding circuit of R38.

40. Holding circuit of R32.

At the end of the second impulse R33 re-energises.

41. R41 energises.

42. R41 locking circuit.

43. New circuit for R36.

Should the first digit dialled be 2, R33 remains energised, and R35 de-energises, as circuit 35 is open at R33. R32 is held energised over contact 40.

44. Circuit for M44, corresponding to the 200-line group of connectors. The arms are moved round by interrupted current.

Should the first digit dialled be 3, R33 again de-energises for the third impulse ; but R35 is not de-energised, because it is made slow to de-energise. Circuit 43 is open and R3 de-energises. Contact 43 at R36 is open, so that R36 cannot re-energise when R33 re-energises. When R33 does re-energise to complete the final impulse of the first digit, R3 de-energises.

45. The discriminator driving magnet M45 of the 300-line group now energises, and drives the wipers to the terminals of an idle connector in the 300-line group.

The discriminator selector, according to the position of the contact 44 or 45 of R36, finds an idle connector.

46. R46 energises in series with RR3 of the connector.

47. The 10-ohm winding of R46 is inserted in the C wire.

48. The driving circuit of M44 (if the call is in the 200-line group) is open, and the discriminator arms are brought to rest on the terminals of the selected line.

49. Circuits 30 and 33 are opened at R46, and the loop 5 from the preselector is joined through to the loop 5 of the connector. R30 and R33 de-energise. R3 of the preselector and R 46 are held energised in the third conductor, through their low-resistance windings, and the circuit tests busy to other discriminators.

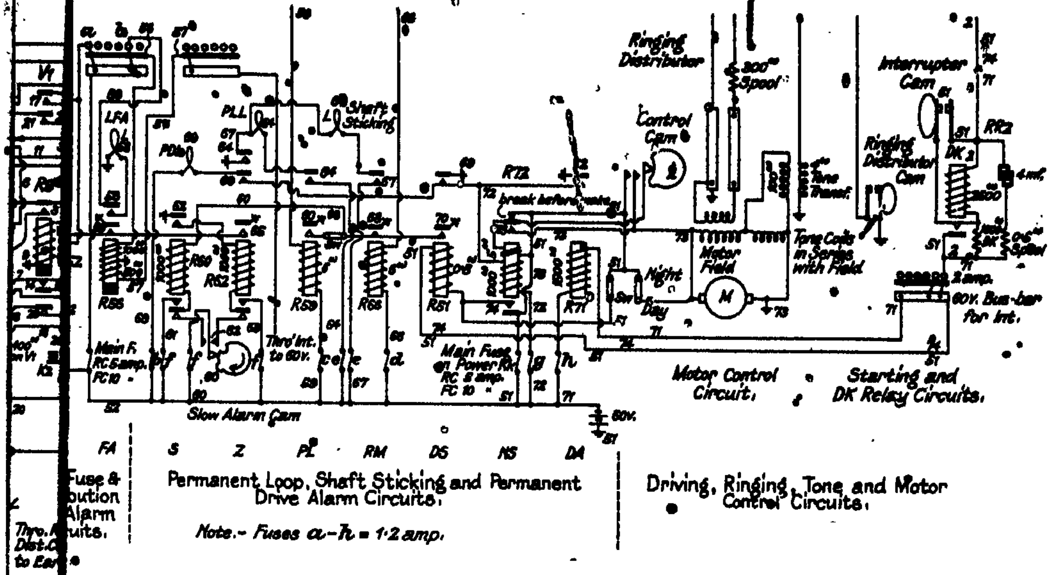
Circuit 32 is open and R32 de-energises. Circuits 35, 38, and 41 are open, and R35, R38, and R41, de-energise.

50. Short-circuit about the 600-ohm coil of R46. Circuit 34 is open, and the lamp ceases to glow. R46 only is energised.

Release.

Circuit 3 is opened and R46 de-energises. R3 of preselector de-energises first, because R46 is made slow to de-energise by the short-circuited 600-ohm coil. Circuit 48 is closed and the discriminator arms rotate to normal.

Fig. 89. Siemens' Private Automatic Exchange Control and Alarm Circuits.



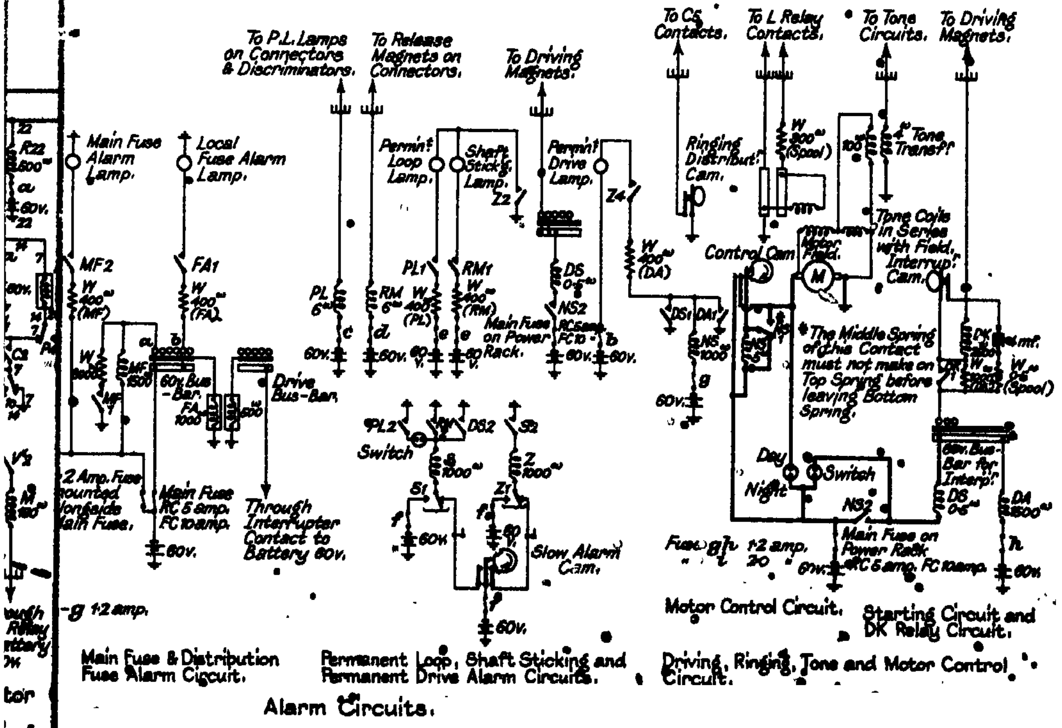


Fig. 90. Key Diagram for above.

Section 46

OPERATION OF POWER AND ALARM CIRCUITS: SIEMENS AUTOPHONE SYSTEM (Figs. 89, 90, and 91)

The exchange is operated from a 60-volt battery of accumulators. A small dynamotor (Fig. 93) driven from the battery, supplies the ringing and tone currents. This machine also operates a number of springs, by means of cams, to provide interrupted driving current for the preselectors. Reduction gear and slow-speed cams control the alarm circuits provided.

The machine is controlled by a *day* and *night* switch fitted on the power panel. When the switch is thrown to the *day* side, the machine runs continuously, and when thrown to the *night* side it is normally stopped, but commences to run as soon as a call is made. When the machine is started by a call, under the latter conditions, it is kept running for a period of two minutes, after which, if no further call is made, it automatically stops. If the call is unanswered within two minutes, a tone given to the caller will cease, and the call can then be cleared or a further one made. It is only necessary for the machine to run during the setting-up of the connection.

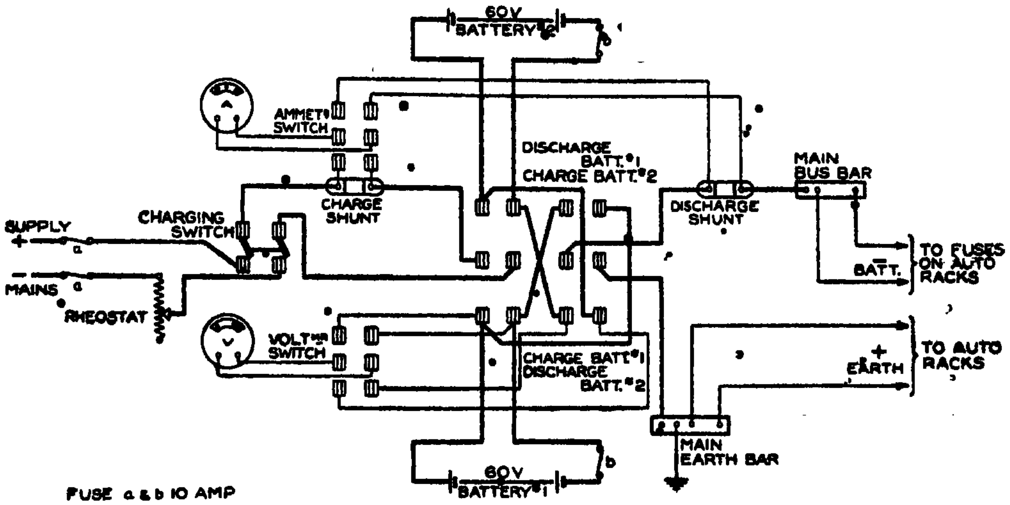


FIG. 91.—POWER CIRCUIT FOR PRIVATE BOARD (SIEMENS).

An alarm bell and lamp signal are provided to call attention to abnormal conditions, such as the breaking-up of a fuse, or a receiver not replaced. In the latter case a time-lag device is introduced into the alarm circuit by means of a cam on the machine, which prevents the alarm coming into action during normal operations.

Preselector driving circuit.

Preselector driving. The preselectors, and discriminators when provided, are driven by battery current, supplied through interrupted contacts operated by cams on the dynamotor shaft.

When a preselector, or discriminator, is to operate, the circuit of its driving magnet is

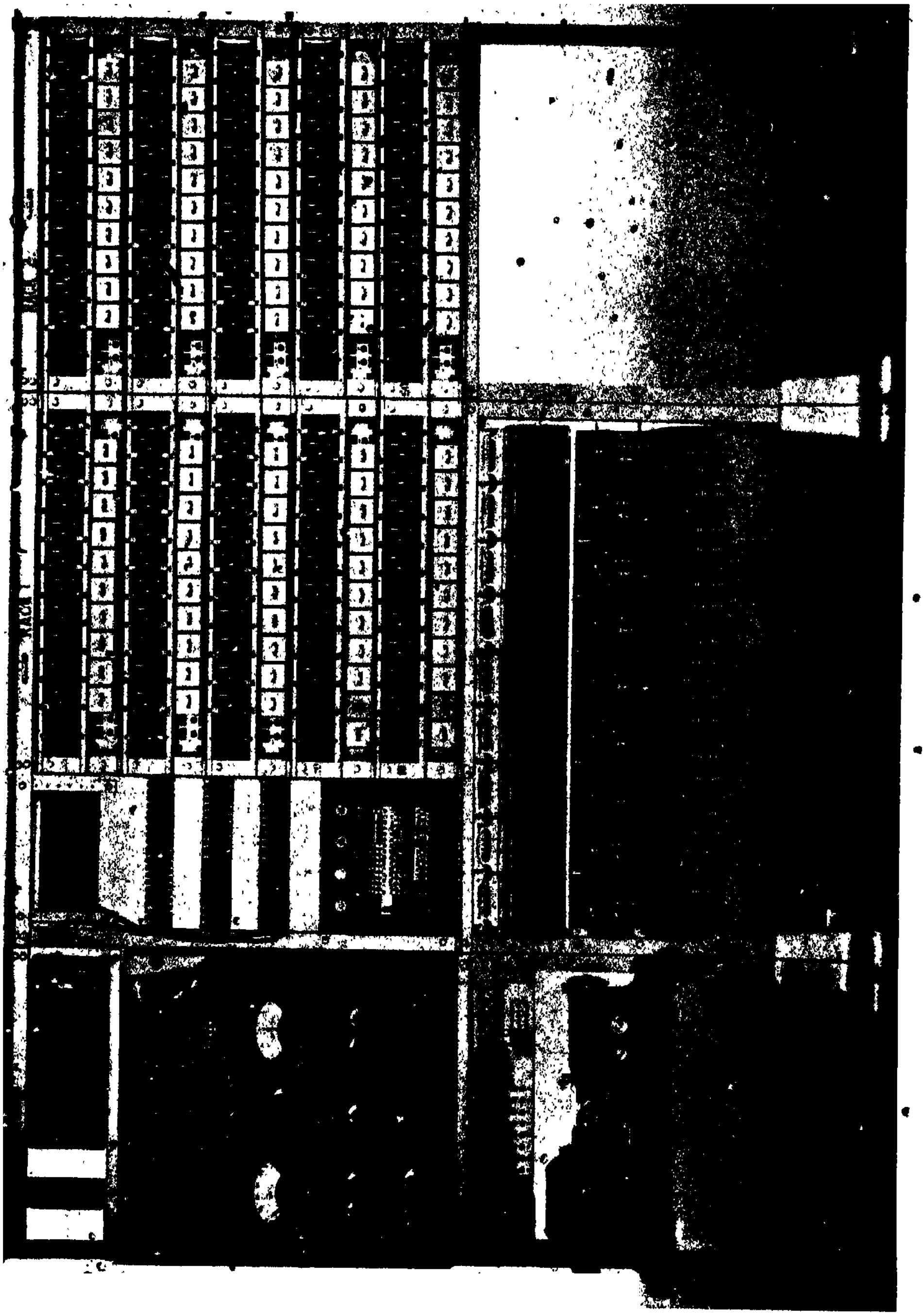


FIG. 92.—SIEMENS AUTOPHONE SYSTEM NO. 2 FOR 100 LINES.

earthed at the controlling relay, and current is supplied from the power panel over the day switch and circuit 51. The current is interrupted forty times per second, and the arms are

FIG. 93.—DYNAMOTOR OF SIEMENS NO. 2 AUTOPHONE SYSTEM.

stepped round. A separate driving lead is provided for each rack.

Each interrupter contact is provided with a relay, RR2(DK), to prevent the interrupter

FIG. 93A.—INTERRUPTER AND RINGING MACHINE (SIEMENS).

magnets being subjected to a continuous current, should the contact fail to open, or be short-circuited. The current through the relay winding of 2500 ohms does not affect the driving magnet. The relay does not de-energise when momentarily short-circuited by the contact. Should, however, the contact be short-circuited by a fault, the relay will de-energise and introduce the 2000 ohms in series with the driving magnet, so protecting it from undue heating. A spark-quenching circuit is provided across the contact.

Ringing and Ringing Distributor Circuits.

Ringing Supply.—The alternating current required for ringing the telephone bells is obtained from a winding on the dynamotor armature, over slip-rings, one of which is connected to earth. A separate pair of leads is taken to each connector-rack, and a 300-ohm resistance is fitted in the supply wire, to prevent the ringing winding on the machine being short-circuited on any of the racks.

Ringing Distributor.—The ringing-distributor contacts are controlled by cams, operated by reduction gear from the shaft on the machine. The leads are earthed for a period of one second in every six, thus giving one second's ring to five seconds' silence.

The Tone Circuit.

The tone, indicating the busy or idle condition of any line, is obtained from tone coils wound on special interpoles on the dynamotor, and energised in series with the field. The tone, which results from the action of the armature teeth on the magnetic field of the machine, is taken through the primary winding of a transformer, and from the secondary it is distributed to the connector-circuits. Earth is used for the return of the tone circuit, so that only one lead is required to each connector-rack.

The Alarm Circuits.

Main Fuse Alarm.—An alarm is provided for the main fuse of each rack. The relay R52 (MF. 1500 ohms) is connected across the main fuse, by means of a special fuse mounted adjacent to the main fuse, and a fuse on the 60-volt bus-bar. On the main fuse melting, due to an abnormal current, R52 energises. The circuit is completed through the earth or short-circuit. Circuit 52 is a holding circuit for R52.

53. The main fuse alarm lamp glows on a particular rack.

54. Circuit of alarm relay R54(AB).

55. Alarm bell circuit.

When the fuse is replaced R52 is short-circuited.

The alarm lamp, relay, and bell receive current through the special fuse, so that the melting of the main fuse does not affect the signal.

Distribution Fuse Alarm.—These are of an alarm type, the spring connecting the main bus bar to the alarm bar. Battery is connected through the 1000-ohm coil of R56(FA), which energises.

In the case of a drive distribution fuse melting, the interrupted current passes to the alarm bar, through the 500-ohm coil of R56(FA) over circuit 57. R56 is slow to de-energise, therefore is not affected by the interruptions, and remains energised.

58. The distribution fuse alarm lamp glows on the particular rack.

59. Alarm relay circuit in which R54(AB) energises, and closes circuit 55 of alarm bell.

Alarm Circuit on Slow-acting Circuit.

Permanent Loop Alarm.—This indicates when a receiver has not been replaced, or the line is earthed, or short-circuited. In such conditions the line is extended to a discriminator, or connector, as if a call had been made. A switch is thus needlessly held as engaged. The position of the switch does not give any indication of the trouble, it being at normal. A lamp is, therefore, provided to indicate such occurrences.

The calling condition must be maintained for a period of two minutes, without impulses being dialled, before the alarm is brought into operation. A *time-lag device* takes care of this.

Time-lag Circuit.—When circuit 8 of the connector, or circuit 34 of the discriminator, is completed, the PL relay is energised in circuit 59. A PL relay is provided per rack of connectors, or discriminators.

The alarm cam, driven by reduction gearing from the dynamotor shaft, makes a revolution in two minutes. The high portion of the cam causes the centre to make contact with the outer spring, and the lower portion of the cam allows the centre to make contact with the inner spring. Between these points both circuits are open.

60. When the high portion is operative R60(S) energises.

61. R60 holding circuit.

62. The cam makes nearly a revolution and then the low portion is operative, and R62(Z) energises.

63. Holding circuit of R62.

64. The permanent loop lamp on the particular rack glows.

65. Alarm relay energised, also that of alarm bell.

The operation depends on circuit 60 being closed for a predetermined time; as, should it release, R60 will de-energise, and cannot be re-energised until the cam makes another revolution.

The switches concerned can now be traced by means of the rack lamp and the permanent loop lamp on the particular switch.

Shaft Sticking Alarm.—This draws attention to a connector which fails to release properly.

66. On the release magnet circuit being closed, current is drawn through the RM relay, common to the rack.

To prevent an alarm being given under normal conditions, the alarm is associated with the time-lag device mentioned.

67. Circuit of shaft sticking lamp on the rack.

68. Circuit of R60(S).

Should the connector stick, the releasing current will not be cut; as K2 will not open and relay, R66(RM) will remain permanently energised. Circuit 65 is closed, and the alarm relay and bell operate.

Permanent Drive Alarm.—This draws attention to preselectors or discriminators driving continuously, which may be due to there being no idle connector, or to one failing to return to normal properly. This is also associated with the time-lag device, so that normal working does not affect it.

In the case of a permanent drive, R51(DS) is held energised in series with the driving circuit 51.

69. Circuit of permanent drive alarm lamp on the rack.

70. Circuit of R60(S).

Should the condition be maintained until R62 is energised, as before described, the lamp glows, and circuit 65 is closed to give the audible alarm.

Motor Control and Night-Starting Circuits.

Night Condition.—When the motor control switch is in the night position, the machine is normally stopped, but commences to run immediately a call is made. The starting circuit is brought into operation by the closing of the preselector driving-magnet circuit.

71. R71(DA) energises in series with a 1000-ohm resistance, RR2 (or interrupter contact), over drive bus-bar on rack, to driving magnet, and earth. R71 energises.

72. R72(NS) energises.

73. Motor circuit.

74. R71 is short-circuited by ·5 winding of R72, and connecting battery to the 60-volt interrupter bus-bar, thus providing current to operate the driving magnet of the calling preselector. During the time the preselector is driving, relay R51 is held energised and completes a holding circuit for R72.

Circuit 73. R72 is held energised in series with the dynamotor, and does not release when circuit 69 is opened, when the preselector completes its drive. The motor-control cam, which is driven by reduction gearing from the shaft of the machine, now operates the motor-control spring set, which, on closing its first contact, called the early-closing contact, makes the motor circuit independent of R72. Its second contact, called the late-closing contact, closes immediately thereafter, short-circuiting the ·5-ohm winding of R72. R72 is thus de-energised, unless still held over circuit 69.

The control-spring set remains in this condition, with both contacts closed, for twelve seconds, the cam then allowing the late-closing contact to open, but keeps the early-closing contact closed. Circuit 72 is now completed, R72 winding is short-circuited, and the machine is kept running from battery through R72. The dynamotor continues to run until the control cam reaches its normal position, and the early-closing contact opens.

If a further call is made whilst the dynamotor is running, and both control contacts closed, on the closing of the second driving-magnet circuit, R71 is again energised, and also R72 in circuit 72. Circuit 74 closes and current is supplied to the driving magnet, R51 again holding R72 during the time driving current is required.

If a further call is made whilst the dynamotor is running, but after the late-closing contact is opened, on the closing of the driving-magnet circuit, as before, R71 and R72 are energised. As the late-closing control contact is now open, circuit 73 will hold R73 energised after R71 and R51 have de-energised. The motor circuit is now maintained over R72, early-closing control contact, and circuit 73 in parallel, dynamotor, to earth.

When the control cam reaches the normal position, and both control contacts open, the motor circuit is still maintained through R72 and circuit 73, and the control cam is driven through another revolution. The control cam proceeds to close both control contacts, R72 is short-circuited, so that it de-energises, and its back contact is closed. The dynamotor is now again under control of the early-control contact, and when the cam reaches normal again, the contact opens, and the machine is brought to rest. The dynamotor is started by any demand for driving current.

The Slow-acting Alarm under Night Conditions.

Condition for Alarm.—In order to ensure that, under night conditions, the motor runs for a sufficient time after the alarm conditions are set up, the slow-acting alarm cam has a definite relationship with the motor-control cam. The high portion of the cam does not close the contact until after the late-closing control contact has been allowed to open.

Alarms are given under the following conditions :—

(*a*) An alarm condition set up when the machine is at rest, or under running conditions, during the period when both control contacts are closed, will cause the dynamotor to run until the control cam has made one complete revolution, thus allowing both the high and low portions of the alarm cam to pass.

(*b*) An alarm condition set up after the control cam has passed the position where both control contacts are closed, and thus, after the high portion of the alarm cam has passed, will cause the motor to run through a further complete revolution of the control cam, after the normal position has been reached, and so allow the high and low portions of the alarm cam to pass a second time, and thus bring in the alarm bell and lamp.

Operation of the Power Circuit.

Charging.—The charging current for the batteries is obtained from D.C. supply mains, or motor generator. A rheostat is provided to regulate the strength of the charging current, and, on closing the charging switch, current is introduced by way of the ammeter shunt to battery No. 1, or battery No. 2, according to the position of the coupled battery change-over switch. The strength of the charging current is measured by throwing the ammeter switch to *charge* (see Fig. 91).

The rheostat is adjusted to give the correct charging current.

The voltage of the battery under charge is measured by throwing towards battery 1 or *battery* 2, whichever is being charged.

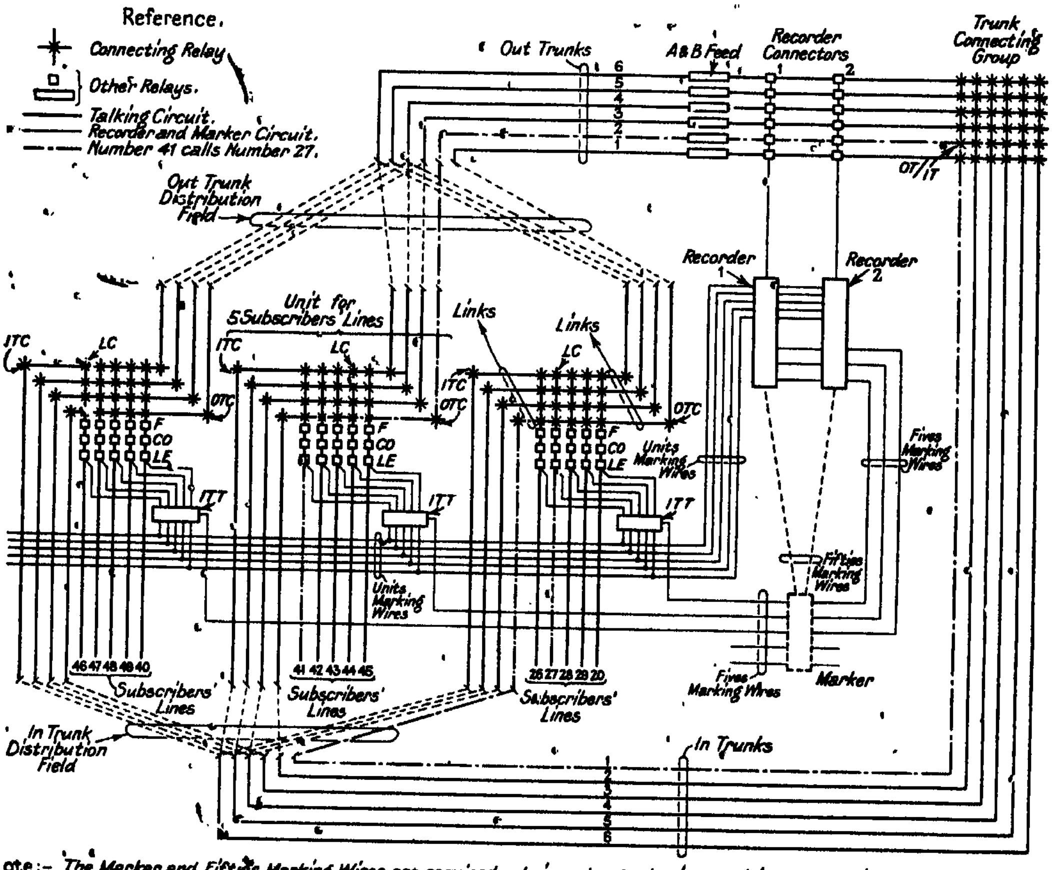
Discharging.—The discharge current for the whole equipment is passed through the discharge ammeter shunt, so that, by throwing the ammeter switch to *discharge*, the strength of this current can be ascertained.

The voltage of the battery is measured by throwing the voltmeter switch, as previously described.

Section 47

RELAY BRANCH OFFICES FOR CAPACITIES UP TO 200 LINES

The Relay Automatic Telephone Company's system has been generally described in Vol. I, page 249, and it is therefore unnecessary to point out its salient features.



ote:- *The Marker and Fifties Marking Wires are required only in exchanges having an ultimate capacity exceeding 50 subscribers, and are shown dotted in this diagram.*

FIG. 94.—TRUNKING SCHEME IN SINGLE STAGE EXCHANGE (R. A. T. CO.).

The apparatus lay-out or schematic diagram is shown in Fig. 94 for a 50-line installation, and Fig. 95 shows a corresponding diagram of connections. For installations above fifty, the principal modification consists in additions to the, so-called, *recorder* and *marker* on the lines indicated in Figs. 194 and 195 of Vol. I. The diagram (Fig. 95) is suitable for a purely private installation or for local connections in a private automatic branch installation in connection with the public service.

Special features will be described in the circuit description. The circuit is numbered as follows :—

Station 27 is to be called.

1. Receiver lifted R′(LE) is energised. The earthed winding on R′ is wound non-inductively. Pilot RR′ also energises.

2. R2(OTT) energises, and closes the out-trunk test circuit.

3. R3(LM), R3′(OTC), RR3(BBM) energise. The thermostat commences to heat. Note that a *link* and its associated out-trunk must be idle. A link has been connected to the *out-trunk* by R3′(OTC).

4. R4(LC) energises. If the call is effective the lamp will not have time to glow fully. The caller is now connected to the link.

5. The out-trunk holding circuit in which R3′(OTC) and R4(LC) are held, and R5(CO) and R5′(F) are energised. Circuit 1 is open and R′, RR′ de-energise. Circuits 2 and 4 are open.

6. Impulse relay R6(A) energises over the caller's loop.

7. R7(G) energises, is slow to de-energise. Test circuit opened to *busy* out trunk and link. R3 de-energises and the lamp ceases to glow. Circuit 5 is now completed over 5′.

7′. The A and B feed lamp L7′ glows fully.

9. R9(RP) energises in series with holding coil of RR3.

10. Finding an idle recorder, R10 (RC1), and R10′(P) energise, and busy lamp L10 (in parallel) half glows. If the first recorder were busy the test wire (T) would be open at BY contacts. RC2 would then energise over BY contacts in the second *recorder*.

11. The *recorder* is prepared. R11(RG) energises and prepared lamp L11 (in parallel) glows.

12. All units relays operate over the contacts of their respective I relays.

13. Relay I1·6 operates.

14. U1·6 de-energises and I2·7 is connected to the *impulse wire* IW over the contacts of all units relays.

The recorder is prepared, but other subscribers still have access to it.

The dialling of the first digit 2 opens and closes the caller's loop twice. R6(A) de-energises on the *first break*.

15. R15 energises in series with the holding coil of R9.

16. New holding circuit of RR3(BBM), R15(FI), R10(RC), in which R16(BY) energises. The latter is slow to release. The recorder test-wire is opened at BY to make the *recorder* busy and inaccessible to other callers.

17. New locking circuit for R10′(P). Lamp L10 is in parallel with R10′ in circuit 17, and now glows fully.

18. New holding circuit for I1·6 in which R18(IH) energises. Until R16 energises, R18 is short-circuited to give ample time for the operation of R11.

19. R11 is connected to the impulse-wire circuit 14. R11 remains energised during the train of impulses.

R6 re-energises on the *make of the first impulse* and R9(RP) de-energises. The impulse circuit 14 is again established.

Second impulse, break.—R6(A) de-energises, connects earth to the impulse wire 14, and I2·7 energises.

20. Holding circuit of I2·7 over circuit 18.

U2·7 is now connected to the impulse wire 14 and will de-energise at the end of the impulse.

Second impulse, make.—R6(A) is re-energised and earth is cut from circuit 14. U2·7 de-energises. I3·8 is connected to the impulse wire. I1·6 holding circuit 18 is opened and U1·6 energises over circuit 12.

In the interval between the first and second digits the I and U relays are as follows:— I2·7 is locked in series with R18(IH), the other I relays being at rest. U2·N is at rest, all others being energised.

R11(RG), being connected to the impulse wire 14, de-energises slowly.

21. TN2·7 energises.

22. R22(TNH) energises in series with TN2·7.

The tens digit is now stored by the locking of relay TN2·7. Circuit 18 is opened, and R11(RG) re-energises. The release of I2·7 allows U2·7 to re-energise. I1·6 is then connected to the impulse wire 14.

Second digit 7.—The counting operations of the second digit are similar to those described for the first except the first impulse, break. There is now no recorder holding circuit to establish.

First impulse, break.—The caller's loop 6 being opened, R6(A) de-energises. Impulse circuit 14 is earthed and I1·6 energises, and locks over circuit 18′ in series with R18.

23. U1·6 is connected to the impulse wire 14 over 23.

First impulse, make.—R6(A) re-energises, opens 14 and U1·6 de-energises. I2·7 is connected to the impulse wire 14.

Second impulse, break.—R6 de-energises. Circuit 14 is earthed and I2·7 energises. I2·7 is locked in series with R18 over circuit 20 and 18′.

24. U2·7 is connected to the impulse wire 14.

Second impulse, make.—R6 re-energises and U2·7 de-energises.

25. I3·8 is connected to the impulse wire 14. Circuit 18′ is opened and I1·6 de-energises and closes a circuit over 12 to re-energise U1·60.

26. The remaining impulses operate corresponding relays in a similar manner. After the fifth impulse is received I1·6 is reconnected to the impulse wire 14, and the counting operations recommence to progress through the I and U relays from 1·6 to 5·0 with the following modifications:—

27. The *sixth impulse, break,* actuates an additional relay R27(U6C) whose function is to differentiate between digits 1–5 and 6–0 at the marking stage. As the second digit is 7, R27(U6C) will operate at the sixth impulse, break, to co-operate with TN2·7 (now locked) to suppress 2 and select 7 at the marking stage.

R18(IH) remains energised until the end of the impulse train.

28. R27(U6C) locking circuit.

When the last impulse is sent in, I2·7 is locked in series with R18(IH), other I relays being at rest. U2·7 is de-energised, and all others energised. R27(U6C) is held over circuit 28.

Marking.—Circuit 14 is opened, R6 being energised after impulsing, and R11(RG) slowly de-energises.

29. R29(MC) energises.

30. R29 locking circuit.

Each *recorder* has an R29(MC) relay, and only one can be energised at a time, therefore only one recorder can control the *marking wires*. Two recorders cannot *mark* simultaneously. It takes less than one-tenth of a second to *mark*.

The operation of R29(MC) will *mark* one of the two fifties *marking wires* with battery, but, as in the present example, there is only one fifty to choose from, these wires are not in use.

31. The out-trunk is marked and ringing prepared. R31'(RG) and R3'(OTM) energise in parallel.

32. R31'(RG) locking circuit.

33. Circuit of the fives marking wire. R33(ITT) energises.

34. Recorder meter energises.

Circuit 10 is open and R10'(P) de-energises slowly. L10 ceases to glow.

35. In-trunk test circuit. R35(LM), R35'(ITC), RR35'(OTM) energise. RR35(ITB) does not energise with current through its test coil only. This relay is differentially wound and operates when the holding coil only is energised.

The *link* is connected to the in-trunk.

36. The called subscriber is marked and R36(LC) energises.

If the line is *busy*, the above circuit is open at F contacts (36'). Busy tone is then given to caller.

37. In-trunk holding circuit. R37(F), R37'(CO) energise, and R36(LG), R35'(ITC), RR35'(OT/IT), R15(FI), RR3(BBM) are held. RR35 does not energise.

38. Ringing circuit. R38(RT) energises when the subscriber lifts the receiver.

R10'(P) does not de-energise until R36(LC) has energised, then all recorder relays de-energise. R16(BY) is made slow to de-energise to keep the recorder busy until all other relays have released. The recorder is now fully released.

R31(OTM) also de-energises. R35(LM) then de-energises and RR35(ITB) energises, the test-coil circuit being open. R33(ITT) de-energises.

39 (partly over circuit 38). The called line is connected to the battery feed relay R39(B), which energises and completes the talking circuit.

R6 controls the release from the caller. If the called party does not replace the receiver promptly, R5'(F) is held over the pilot relay.

41. Pilot relay energises. Thus a trunk cannot be held busy.

42. If the caller fails to release, the thermostat operates.

43. R5', R5, R4, R3' are shunted and release.

Additions and Modifications necessary for Use in the Public Service.—Fig. 96 shows each local line provided with a lamp and jack and how these are associated with the subscriber's unit. Fig. 97 shows a trunk to a common battery exchange, and a cord-circuit for making the necessary connections.

When an exchange connection is set up, battery for the local microphone is provided from the main office.

When an exchange connection is required, 0 is dialled to call-in a local operator who completes connection to a trunk. For inward calls the main office ringing-current operates an indicator, a condenser being in series. Again the local operator completes the connection manually.

Some minor modifications are necessary on the recorder, the nature of these varying according to the capacity of the local office.

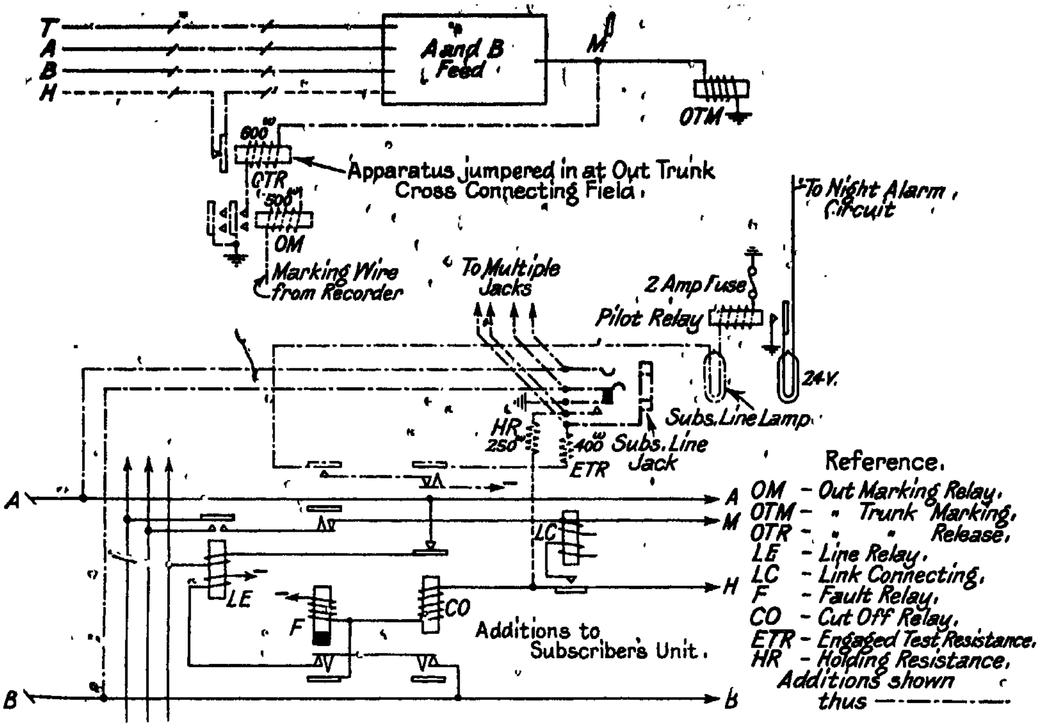


FIG. 96.—ADDITIONS AND MODIFICATIONS TO FIG. 95 FOR PRIVATE BRANCH EXCHANGE WORKING (R. A. T. Co.).

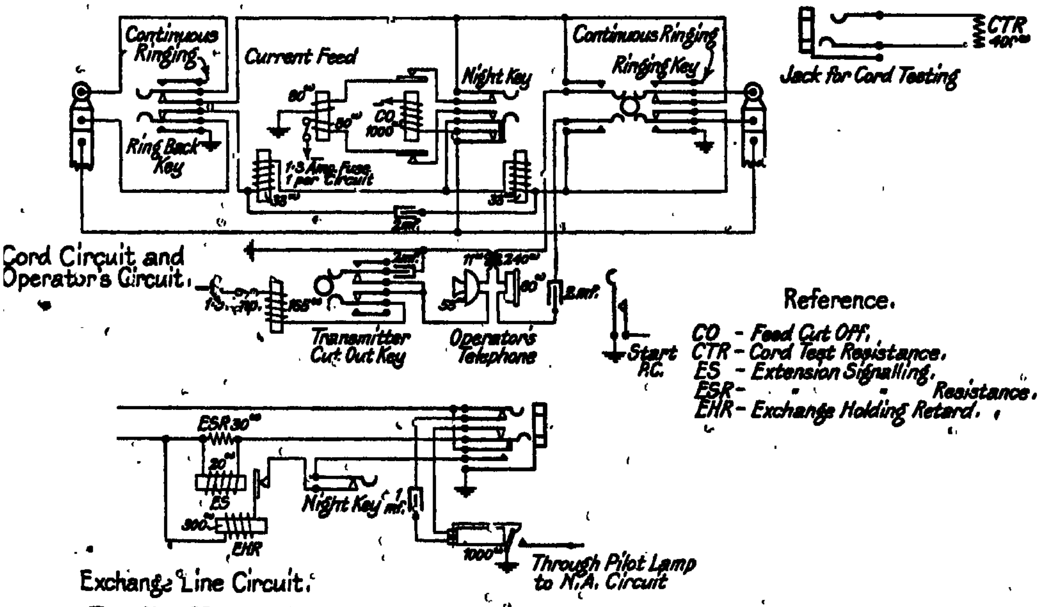


FIG. 97.—MANUAL CIRCUITS FOR PRIVATE AUTOMATIC BRANCH EXCHANGE—NEGATIVE SUPERVISION (R. A. T. Co.).

Section 48

"SELECT-O-PHONE" PRIVATE AUTOMATIC EXCHANGE

This system is being installed by Pettigrew & Merriman, Ltd. (Screw Machine Products Corporation, U.S.A.), for installations up to 33 lines. In addition to direct secret service it provides for *conference* facilities for three or more people and with a *direct call* or *code circuit* for calling to the nearest telephone anyone wanted who may be at some unknown point in the establishment. The circuit is shown in Fig. 98. It is built up in sections as shown in Fig. 99, and therefore can be readily extended. The instrument may be of the type used generally, and Fig. 100 illustrates a convenient design with handset and dial or circular impulse sender attached to the base.

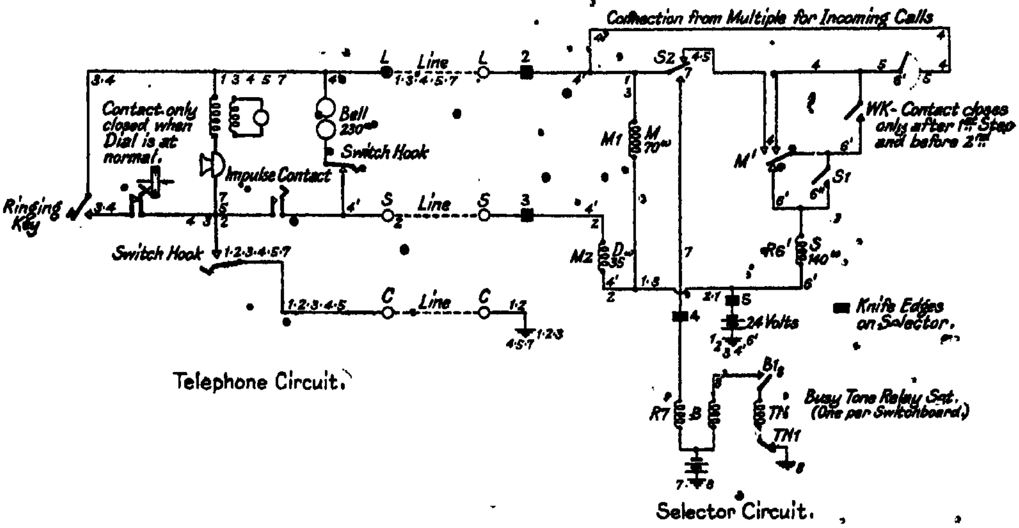

Connection from Multiple for Incoming Calls
Line
L
L
S
Line
S
C
Line
C
Contact only closed when Dial is at normal.
Bell 230ω
Switch Hook
Impulse Contact
Ringing Key
Switch Hook
M1
M 70ω
M2
D 35ω
S2
M'
WK-Contact closes only after 1st Step and before 2nd
S1
R6'
S 140ω
24 Volts
Knife Edges on Selector.
R7
B
B1
TN
TN1
Busy Tone Relay Set. (One per Switchboard.)
Telephone Circuit.
Selector Circuit.

FIG. 98.—SELECT-O-PHONE PRIVATE EXCHANGE CIRCUITS (PETTIGREW & MERRIMAN).

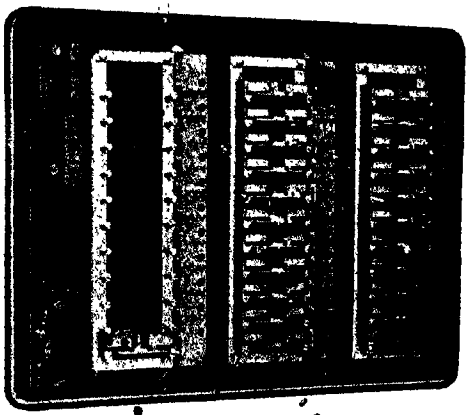


FIG. 99.—SELECT-O-PHONE SWITCH PANEL.

The receiver is lifted *after* the dial has been set to make a call, and a ringing-key depressed after the dial has returned to normal. The dial is locked during conversation to prevent interference.

The dial has two sets of contacts. The *impulse contact* is normally *open*, and is closed intermittently to send impulses. The *ringing-guard* contact is only closed when the dial is at normal. The first setting movement opens the contact to prevent disturbance should the ringing-key be irregularly depressed.

A stepping rotary switch is associated with each line. It has three magnets. D receives the impulses and steps the wiper to the required number. M serves two purposes—holding the ratchet pawl in position during impulsing and switching the line to the talking position. S tests the required line and connects busy tone to the caller if the wanted line is busy.

Magnets M and S have contacts to control the circuits. M has two armatures, one operated immediately the receiver is lifted to insert the pawl into the selector ratchet and so retain it in the position set by magnet D. The second armature is operated after the ringing-key is depressed. Spring set M1 is controlled by this second armature and opens the circuit of testing magnet S when operated. It also connects the line to the wiper for talking.

Magnet S carries spring sets S1 and S2, the former closing a locking circuit for the S magnet, to prevent the busy tone being stopped by the caller depressing the ringing-key wrongly. S2 contact connects the busy tone to the caller.

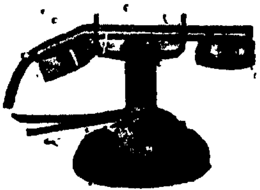


FIG. 100.—SELECT-O-PHONE TABLE INSTRUMENT.

The commutator contact WK is adjusted to close only after the switch has taken its first step and the second is not quite completed. This contact is required for the general call circuit. The contacts are shown in their normal position.

The circuits (Fig. 98) are numbered as follows :—

1. The dial being set and the receiver lifted, the C wire is connected to the switch. Magnet M inserts pawl in the ratchet. The circuit resistance is such that the second armature is not attracted.

2. The impulse circuit is closed a number of times and magnet D is energised a corresponding number of times. The wiper is stepped to the required line.

3. Ringing-key is depressed and short-circuits the transmitter, so that the M magnet pulls up its second armature, which is then held in that position.

4. Ringing-circuit, over 4 of the calling and 4′ of the called line.

The called receiver is lifted and conversation is carried on.

Line busy.

5. When a receiver is lifted, positive battery is connected to the multiple contact.

6. Another party calling this number, his S relay is energised over circuit 5 and locked over contact 6″, so that it is independent of contacts M1 and S2.

7. Busy tone control-circuit. Relay B energises.

8. Tone relay TN energises and busy tone is induced in the second winding of B.

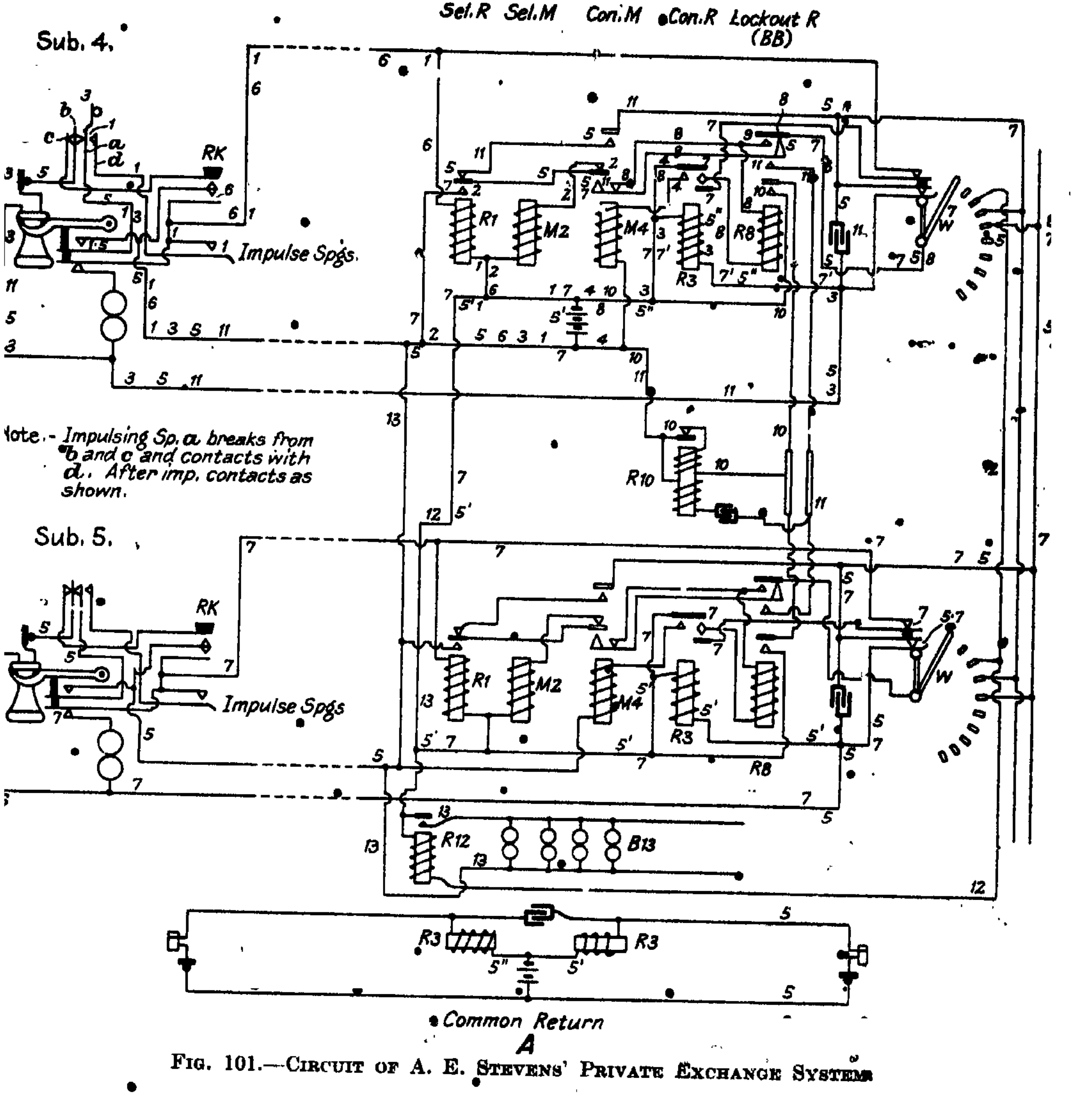
Ringing.—The bell is rung by lowering the resistance at the calling instrument. Ringing ceases because the bell is shunted by the M magnets of the calling and called lines in parallel.

General Call.—The general-call relay is controlled from the first contact of the multiple. The WK commutator is not closed, and consequently the S magnet is not connected to the wiper. The line is therefore not busy. This allows the call to be answered from any telephone.

Section 49

A. E. STEVENS' P.B.X. WORKING

The switches have a capacity of 100 lines and have 100 contacts arranged in a circle, a single wiper being used. The switch has also a set of contacts controlled by an arm, which are opened when the switch makes a call. One switch per line is fitted. The dial also has a capacity for 100 lines, and for, say, No. 90, ninety impulses are sent out.



Note.- Impulsing Sp. a breaks from b and c and contacts with d. After imp. contacts as shown.

FIG. 101.—CIRCUIT OF A. E. STEVENS' PRIVATE EXCHANGE SYSTEM

Other features will be described with the circuit operations.

Fig. 101 is a diagram of connections, the circuits being numbered as follows :—

Suppose No. 4 calling No. 5.

1. When the receiver is lifted and the dial pulled to 5, R′ energises five times.

2. The selector magnet M2 energises five times. The wiper W moves to the fifth contact.

3. Connector relay R3 energises.

4. Connector magnet M4 circuit.

5. The caller is connected to the called line (this circuit is completed when the called receiver is lifted to answer).

5′. R3 of called line is energised.

6. Ringing-key at instrument RK is pressed and R′ energises, to ring the called party.

7. Ringing-circuit over called line. The direct current bell is rung whilst the key RK is depressed.

The talking-circuit is over a common battery lead. The theoretical talking-circuit is shown at A.

8. If the called party is busy, R8 energises.

9. The busy circuit is then completed over contact 9.

10. R10 is energised interruptedly.

11. Busy tone is given to the caller.

When the calling receiver is replaced, R3, and then M4, de-energise to break down the connection.

12. A circuit is multipled over all the switches as a general call. When a call is made to this line, R12 energises.

13. The parallel bells all ring. A particular code is sent to bring the particular party to a telephone.

A plurality of lines are provided for exchange service.

Section 50

THE COUCH AUTOPHONE SYSTEM OF P.B.X. WORKING, AS USED BY THE PRIVATE TELEPHONE AND ELECTRIC COMPANY

This is an automatic system designed to take the place of the well-known intercommunicating system. This is a 3-wire system. The switch, of which one is required per line, is a circular one with 100 contacts and 1 wiper. Fig. 103 is a front view of the switch showing the numbered contacts. Fig. 104 is a rear view showing the two magnets. Fig. 102 is the

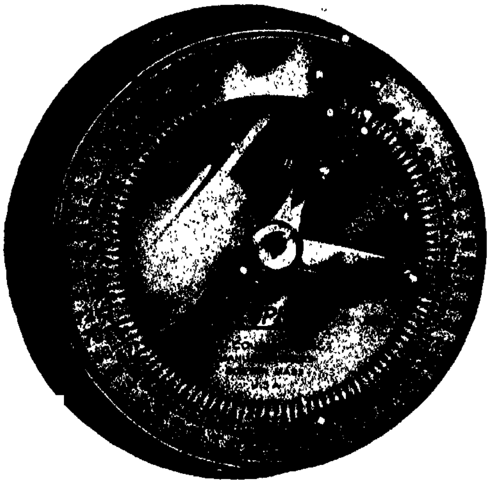


Fig. 102.—Couch 100-point Dial (Pr. Tele. and Elec. Co.).

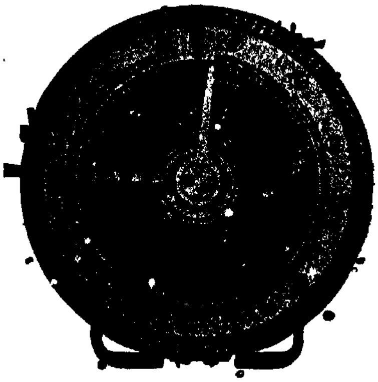


Fig. 103.—Couch Individual Selector. Front View.

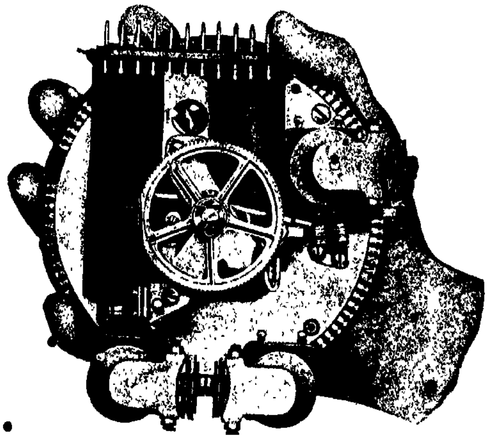


Fig. 104.—Couch Selector. Rear View.

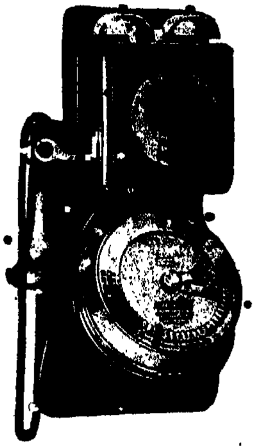


Fig. 105.—Couch Wall Set.

00-point dial with operating levers and ringing-key. A, B, C at the beginning of the scale represents three exchange lines. Fig. 105 shows the type of wall instruments used.

Besides the usual local and exchange facilities, the arrangement has several interesting features.

Conference Facilities.—When one party calls another and information is desired from a third party, the one called may call in the third, the third may call in a fourth, and so on.

General Call.—When a party is not in his office, but is known to be in some other part of the building, a number may be called which will ring bells situated at various points. The ringing is in code, and the party, identifying the code, steps to the nearest telephone, when he is in direct communication with the party calling.

The switchboards are made in various sizes, from 15 to 100 lines.

As there is a switch per line carrying contacts for the whole of the installation, it will be understood that every line may be talking at the same time.

Section 51

VILLAGE AUTOMATIC EXCHANGE SYSTEM, 100 LINES' CAPACITY (SIEMENS)

This automatic equipment meets the particular requirements of villages and small towns where the cost of constant attention would be high.

This equipment, which is of the full automatic 2-figure type, may be left unattended for any period up to one week, a system of alarms having been arranged to call attention to any faults which may occur.

The facilities provided include bothway junction working to C.B., C.B.S., magneto, or trunk exchanges, and party-line working, by means of an automatic code-call system.

The following signals, which have been standardised by the British Post Office, are also provided :—

1. Dialling signal ; a *continuous* clicking noise of a comparatively low frequency, to inform the calling subscriber that dialling may commence.

2. Ringing signal, an *interrupted* clicking noise of the same frequency as the dialling signal to inform the calling subscriber that the called subscriber is being rung.

3. Busy tone, an *interrupted* tone of a comparatively high frequency to inform the calling subscriber that the called subscriber is engaged.

4. Number unobtainable tone, a *continuous* tone of the same frequency as the busy tone, to inform the calling subscriber that the called subscriber is unobtainable, as, for instance, when the called line is out of order.

Transmission.—The " noise-proof cord-circuit " system of transmission is employed, which consists of repeating coils with condensers and relay and impedance coil battery supply.

Batteries.—Duplicate 40-volt batteries each of 60 ampere-hours' capacity are provided. Each battery is capable of operating the exchange for approximately three days.

Power Plant.—The arrangements for charging the batteries can be varied to suit the local conditions.

Where a supply of electricity is available the batteries can be charged either through a resistance or from a motor-generator set. Alternatively, a portable charging set can be used.

For exchanges where none of the above methods are suitable, a generator driven by a petrol engine is provided. This can be either started by hand, or can be automatically controlled, as described later. The charging of the battery can be stopped automatically if desired, by a modified form of ampere-hour meter.

Test Set.—Suitable testing sets are provided to enable every part of the equipment to be systematically tested, so that in many cases faults will be detected before any trouble results on the equipment.

Capacity.—The equipment has an ultimate capacity of 100 subscribers' lines or 90 subscribers' lines and 10 junctions, with selector switches to enable 14 simultaneous connections to be made.

A main distributing frame, with capacity for 100 lines, is provided, and this carries, in addition to the protectors and fuses, the apparatus for connecting faulty lines to the *number unobtainable* tone-circuit.

Racks.—A 100-line equipment consists of two racks.

These comprise a main rack with capacity for 50 lines (including junctions) and 8 selector switches (Figs. 106 and 107), and an extension rack with capacity for 50 lines and 6 selector switches.

Equipments can be provided for any number of lines and selector switches up to the ultimate, and the racks are so designed that switches can be added as required, without any alteration to the existing apparatus, or interference with the exchange service.

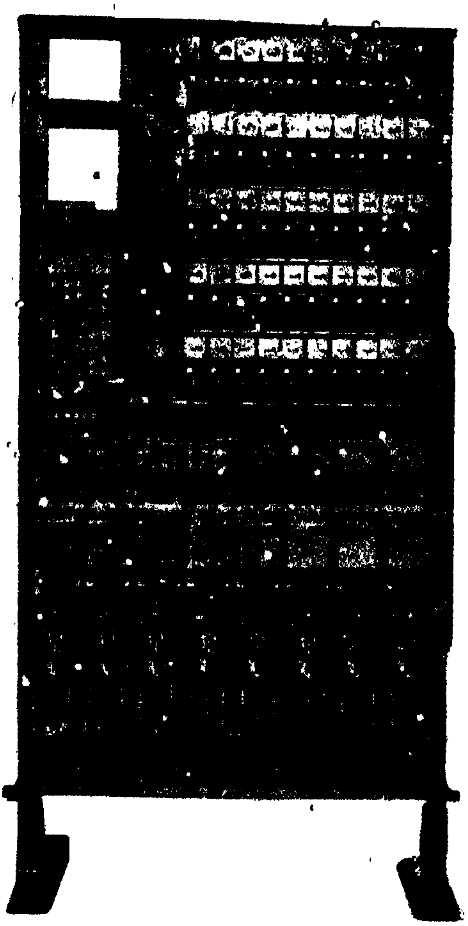


FIG. 106.—VILLAGE AUTOMATIC EXCHANGE EQUIPMENT, 50-LINE RACK (SIEMENS). FRONT VIEW.

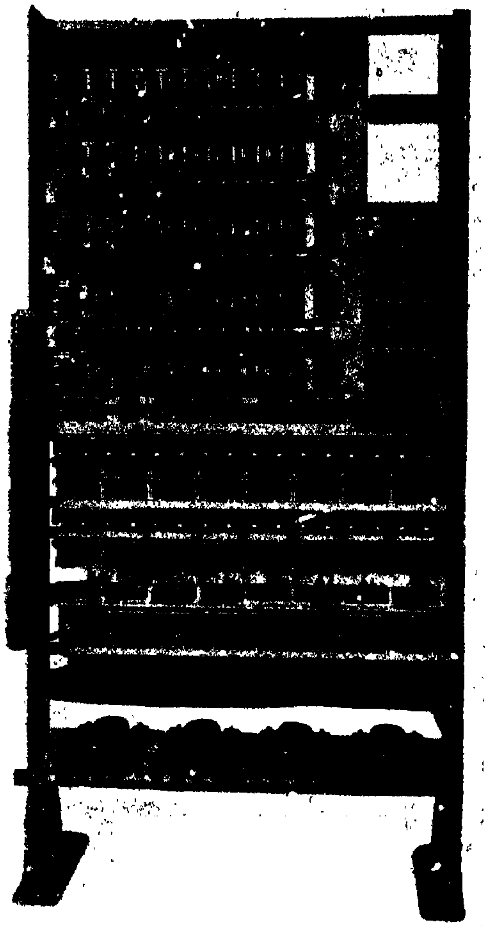


FIG. 107.—VILLAGE AUTOMATIC EXCHANGE EQUIPMENT, 50-LINE RACK (SIEMENS). REAR VIEW.

All equipments are wired to the full capacity of the rack, thereby reducing to a minimum the amount of wiring to be done on site, when an extension is being added.

Telephone Instruments.—The telephone instruments supplied with the equipment may be either of the type supplied to the British Post Office or of the convertible wall or table hand-microphone type (Figs. 135 and 136).

Preselectors.—Each line is provided with a preselector which is driven by interrupted current, and its function is to extend the calling line to a disengaged selector (connector) switch, and so place the selector under the control of the dial on the telephone instrument.

The preselectors are arranged in panels of ten.

Selectors (Connectors).—The selector is the automatic switch, having both vertical and rotary motion, by which the connection is set up, the tones transmitted and ringing sent out.

The whole of the lines on the equipment are connected to its contact banks which are arranged in ten levels, each of ten sets of contacts.

A shaft carrying three wipers is lifted step by step by the first set of impulses received from the subscriber's dial and comes to rest with the wipers opposite the wanted level. The second set of impulses serve to rotate the wipers until they are brought to rest on the contacts of the wanted line.

The shaft is released and falls back to its normal position when the receiver is replaced on the hook.

Relay Sets.—Associated with each selector are two relay sets, one containing two relays and two retard coils and the other containing eight relays.

These relay sets are fitted with knife contacts. Spare sets are provided, in order that a faulty set may be replaced and the full service of the exchange maintained while it is receiving attention.

Motor Interrupter.—The machine provided for supplying the ringing, tones, signals, and interrupted current for the system has been specially designed for these automatic systems.

It is driven from the exchange battery and requires a very small current. Its circuit is so arranged that it starts up when a subscriber makes a call, and is idle when no calls are in progress on the equipment.

The machine is similar in appearance to that shown in Fig. 93A.

The current for driving the preselectors and selectors is interrupted by contacts operated by cams driven direct by the motor shaft, while a third cam is used to supply the signal current used for the dialling and ringing signals.

The ringing, ringing signal, and busy-tone interrupters are cam-operated contacts which are driven through reduction gearing from the generator shaft, and two cams associated with the alarm system are also driven through suitable reduction gearing.

Metering.—Provision is made for the automatic metering of calls, except in the case of junction calls, when a ticket is made out against the calling subscriber by the manual operators.

The meters themselves are mounted on a separate rack which can be placed in any part of the exchange building.

Testing.—A voltmeter test-set can be supplied with the equipment, by means of which tests on a line can be made with the exchange apparatus cut out of circuit, or calls passed from the test telephone through the automatic equipment with the outside line cut out of circuit.

Further, a routine test box can be supplied, by means of which the automatic equipment can be periodically tested, in order that conditions which would eventually cause faults may be located before any trouble results on the equipment.

The testing is effected by means of a jack associated with each selector and the conditions reproduced in the routine tester are more severe than would exist in normal working, nd, therefore, if the circuits pass these tests, the ordinary working variations should have o effect on the reliability of the service.

Number Unobtainable Tone.—Faulty lines are plugged up to the number unobtainable ne-circuit on the main distributing frame, and dead numbers are permanently connected o the tone, so that a subscriber calling either a faulty line or a dead number immediately eceives the N.U. tone.

Junction Working.—On an equipment giving junction facilities all subscribers are onnected to contacts in the first nine levels of the selector banks, while only junction lines re connected to the tenth level.

The incoming end of each junction is terminated on a preselector in the automatic xchange in the same way as a subscriber's line.

The outgoing ends of the junctions at the automatic exchange are connected to contacts n the tenth level of the selector banks.

Where only one group of junctions to the same exchange is equipped, these will be called y dialling "01," thus raising the selector wipers to the tenth level and rotating them to the ontact of the first junction in the group.

If the first junction is engaged, the wipers will then be rotated automatically over the emaining junctions until a free one is found. If all the junctions are engaged the wipers will continue to rotate until the eleventh contact of the level is reached, when the selector will stop and give the busy tone as usual.

When two or more junction groups are required a contact at the end of each group is onnected to the busy signal and the selector is thus stopped, after having searched the particular group, and busy signal is applied. In this case, the various groups are called by rotating the selector by means of the dial to the contact in the tenth level corresponding to the first junction in the group required.

Thus the first group would be called by dialling "01," the second by dialling, say, "05," and the third by dialling, say, "09."

The general circuit arrangements for junction working are in conformity with the standard practice of the British Post Office. No special apparatus is required at the automatic end of the junction other than the normal preselector equipment.

The calling signal is operated by current over the B wire from the calling end, and the supervisory signal is controlled by current over the B wire from the called end, a cross being inserted in the junction to allow these signals to be received on the A wire at the called and calling ends respectively; the feeding circuit of the selectors is arranged on standard cord-circuit methods.

By using the above principles, it is possible to give full supervisory facilities on junctions to C.B.S. and magneto exchanges, by inserting in the junction at the manual exchange the usual apparatus for converting these to C.B. conditions. In the case of junctions to a magneto exchange, it is not absolutely necessary to provide the calling operator with a clearing signal actuated by the called automatic subscriber, since the automatic equipment being provided with "double release," the called line is automatically cleared when the receiver is replaced, and the called subscriber cannot be held up due to failure of the manual operator in clearing. A simplified junction circuit for magneto working can therefore be used temporarily for subscribers' lines by disconnecting them from the tenth level contacts and strapping them to contacts in another level which is not equipped with preselectors.

To provide the supervisory signal required for junction working, a special B wire is taken from the selectors, and is substituted for the ordinary B wire on the multiple of the preselectors in the junction panel. This B wire passes through a contact of the relay controlled by the called line, so that a supervisory signal is passed back *via* this relay contact to the calling exchange.

The preselectors used for junctions with supervisory facilities also require their circuit slightly modified, so that they call with battery instead of with a loop. This involves only a very slight modification of the wiring, and can be done on individual preselectors as required.

A junction-faulty key is provided in the C multiple wire of each junction preselector, which, when thrown, prevents a junction which is out of order from being picked up by a selector.

An auxiliary equipment is provided at the automatic exchange for each junction, the function of which is to ensure that the junction is marked engaged on the selector multiple as long as a plug is inserted in the jack at the manual exchange. The auxiliary equipment is so arranged that a calling subscriber at the automatic exchange receives a ringing signal as soon as he makes connection to a free exchange line; this continues until the manual operator answers.

Section 52

SIEMENS VILLAGE EXCHANGE

The Connector (Final Selector).—The preselector and the final selector generally operate in a manner similar to that described for Fig. 85, P.A.X.

The preselector and meter are not shown in the present circuit, but it is to be understood that they are similar to Fig. 72, Vol. I. The continuation to the final selector is shown in Fig. 108, and the circuits are numbered in the order of operation.

3. When a selector is taken into use relay T (Fig. 85) of the searching preselector is operated, also R3(AA). The A and B wires are extended to the selector.

4. Holding circuit of R3.

5. R5(A) and R5′(A′) energise over the loop.

6. R6(V) energises.

7. The circuit of the preselector testing relay is independent of circuit 3, contacts E3 and K3.

8. Relay R8(E) energises.

9. Short-circuit on R13 and R13′.

10. Permanent loop relay R10 energises. If this circuit is maintained for a predetermined time, an audible alarm signal is given.

11. A further short-circuit on R13′ to prevent it operating during the first series of impulses. Circuit 3 is opened and R3 is held over circuit 4, and is thus dependent on R5 and R5′.

12. Dialling signal or tone given to caller.

First digit impulses sent in. R5 and R5′ respond to the number of impulses in the digit. R3 also responds over circuit 4. R6 is slow to release and does not respond.

13. On the first de-energisation of R3(AA) the short-circuit 9 is opened and R13(F) energises. Short-circuit 9 is opened at F′ and prevents the subsequent closure of AA3 from again short-circuiting F300.

14. AA3 short-circuits R8(E) intermittently, but it does not release during the train of impulses.

15. Each closure of AA3 by R3 now raises the shaft one step.

16. AA1 completes the circuit of R16(YY), which energises.

17. Holding circuit of R16. Circuit 12 is opened and cuts the dial tone from the line.

18. Holding circuit for R6(V) when contact K′ opens.

The K contacts are opened at the first vertical step. K2 prepares the rotary magnet circuit.

19. K7 holds the connection independently of contact ZB.

At the termination of the tens impulses R3 remains energised over circuit 4.

R8(E) is now released, due to being permanently short-circuited by F′ and AA3 over 14.

Contact E2 opens the vertical magnet circuit 15.

E′ opens the short-circuit 11 and short-circuits contact AA3, to prevent the operation of relay E during the units train of impulses.

20. Short-circuit about relay R13′(G).

The units impulses are now dialled. At the first impulse of R3(AA) the short-circuit 20 is opened, and R13′ operates in circuit 13. Contact G′ opens short-circuit 20, thus preventing AA4 from again short-circuiting G300.

21. Intermittent short-circuit on R13(F), which remains operated during the train of impulses.

22. For each closure of AA2 the shaft is rotated one step.

At the termination of the impulses, R3 is held energised over 4. The short-circuit 21 is maintained across R13, which releases.

23. R23 energises over the C wire to the preselector of the called line.

Short-circuit 14 is opened, and R8(E) again energises.

R13′(G) is short-circuited over E′, circuit 11. Relay G is slow to release and, between the closing of F3 and opening of G3 (circuit 23), R23(P) tests the called line. If the called line is idle, R23 energises over the C wire to the called preselector T relay and earth. The T relay energises and disconnects the selector R relay from the line.

24. R23(P) holding circuit, which also makes the called line test busy.

25. *Ringing circuit to called party.*

Circuit 22 is opened to prevent the wipers being rotated when R13′(G) releases.

26. Ringing tone to caller.

When the call is answered the increased current energises R25(TR).

27. R25(TR) holding circuit (TR′ operates in advance of the other contacts, and opens the short-circuit across TR400).

Earth is disconnected from the A wire (circuits 12, 25, 26 opened).

28. TR3 joins the B wire through to the caller. R28(Y) energises.

Circuit 17 is opened and R16(YY) de-energises.

29. Holding circuit for R6(V), preparatory to release of YY.

Metering.

30. R16(YY) is slow to release and metering current is momentarily applied to the called meter—the current in the C wire being momentarily increased. The release of R16 opens the circuit to the C wire, but the meter remains energised by the normal current. If the called line is busy, its C wire bank is either disconnected when engaged on an outgoing call, or is at a potential only very slightly below that of the battery—when engaged on an incoming call. There will be, therefore, at most only a very small current through R23(P) which will not operate.

31. When R13′(G) releases, interrupter current is connected to the rotary magnet RM22, and the wipers are stepped round to the eleventh contact of the level, to operate the VW contacts.

32. R23(P) and R16(YY) energise, over the C wiper arm. R16(YY) is now held energised by its 400-ohm coil and independent of circuit 17.

33. R25(TR) energises over the B wiper.

34. Busy tone to caller, over the A and B wires.

34a. While busy tone is being transmitted, R28 is intermittently operated by current through the tone transformer and A wire, to provide a lamp-flash signal should the call be a junction call originated by a manual operator.

The meter circuit 30 is open at VW1. The connection is held over circuit 32.

Release.

When either the caller or called party replaces the receiver, the selector is released.

When the caller acts first, R5(A) and R5′(A′) de-energise.

Circuit 4 is opened and R3(AA) de-energises.

Circuit 29 is opened and R6(V) de-energises.

Circuit 19 is opened and releases the calling preselector.

Circuit 32 is opened and releases the called preselector and R23(F) de-energises.

Circuits 8 and 10 are opened by V3 and prevent the further operation of the impulse relays when R23 is released.

35. Release magnet M35 energises to return the switch to normal.

When the called party clears first R28(Y) releases.

Circuit 29 is opened and R6(V) de-energises.

The selector is released as before described.

The calling preselector, being released, drives on and engages the next idle selector (connector) until the caller clears.

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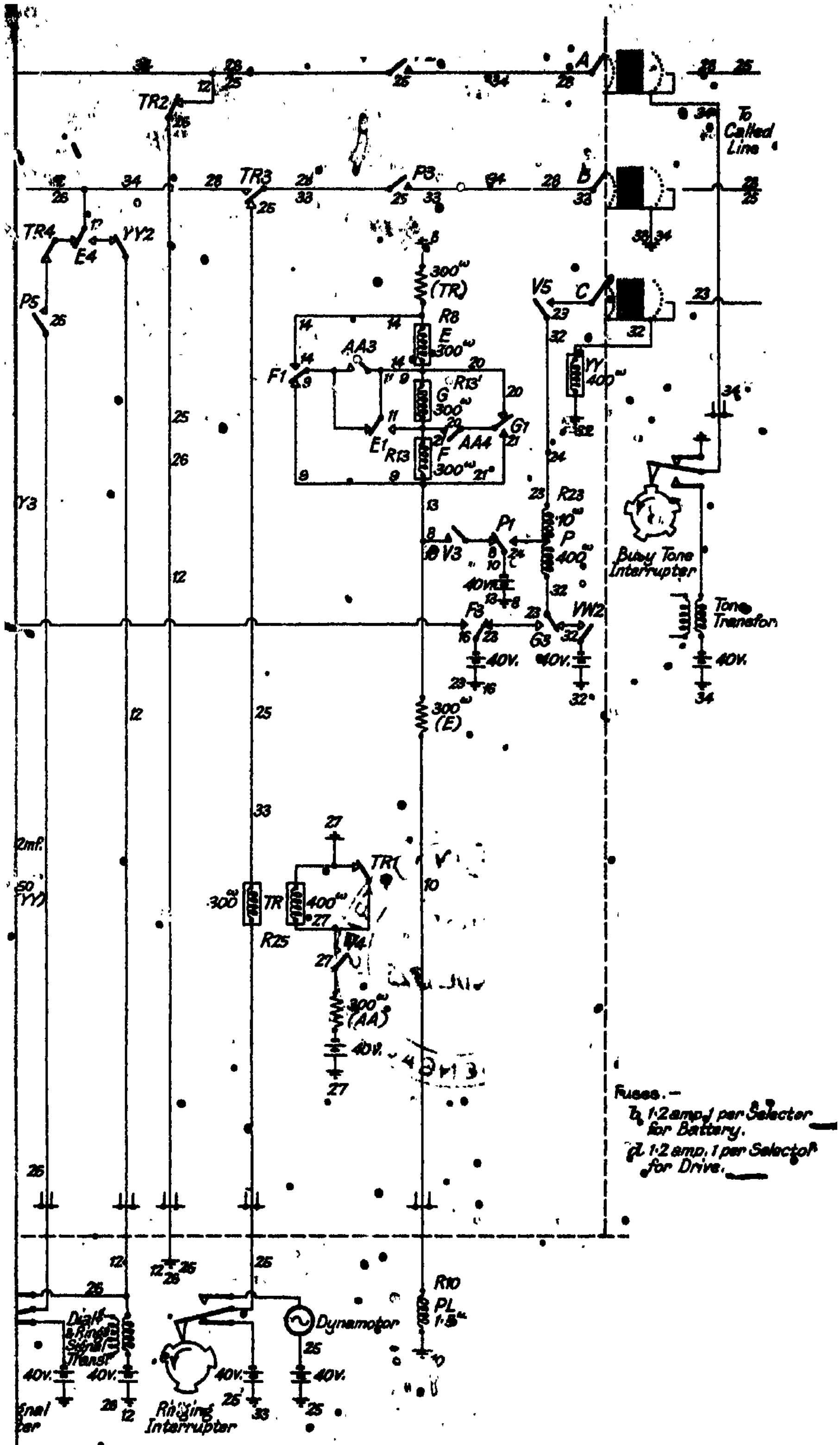


Fuses.—
b, 1·2 amp. 1 per Selector for Battery.
d. 1·2 amp. 1 per Selector for Drive.

E EXCHANGE (SIEMENS'). SELECTOR CIRCUIT.

Section 53

VILLAGE EXCHANGE—JUNCTION WORKING (SIEMENS)

Operation of Selector-Circuit when used to Call a Junction.—When a call is made to a distant exchange, the number dialled will be the number of the first junction in the group to the required exchange. As all junctions are connected to the tenth level of the selector banks, this will raise the wipers to the tenth level, and at the first rotary step made the contacts VW1 and VW2 are operated.

Contact VW1 (circuit 30, Fig. 108) opens, and thus prevents the metering impulse from contacts Y1 and YY1 from reaching the caller's preselector circuit.

If the first junction in the group is idle, the selector will test and make connection with it in exactly the same manner as with a subscriber's line. If, however, the first junction is engaged, then R23(P) will fail to operate between the release of F3(R13) and G3(R13′), and the selector will then be automatically rotated exactly as in the case of calling a busy subscriber's line.

In this case, however, contact VW2 is closed, and a testing circuit is thus provided for relay R23(P) over circuit 32 to the C wiper of the selector, then over the junction-faulty key, G1, N500 to earth.

When an idle contact is reached, the selector will be stopped by the operation of relay R23(P), and will thus connect the calling line to the junction selected.

At the end of each group of junctions, a busy contact, which is connected in multiple with the eleventh contact, is provided. If, therefore, all the junctions in a group are engaged, the selector will always stop on the busy contact following the group, and will connect the busy signal to the calling line.

When the selector has stopped on the busy-signal contact, the A wire, in addition to being connected to an interrupted busy tone, is also connected to an interrupted battery, which serves to operate relay R28(Y) intermittently, and thus to transmit a lamp-flashing signal to the calling operator.

Operation of Bothway Junction to C.B. Exchange (Fig. 109).

Operation of Outgoing Call to C.B. Exchange.

40. When this junction is picked up, the selector tests in by battery over the C wire through relay R23(P), relay R40(N) is thus operated over contact G1 and at contact N1 closes a locking circuit for R40.

41. Contact N4 closes and operates the R41(T) relay in the preselector circuit, thus taking the R relay off the line. Relay R41′(G) is also operated in series with relay R41(T).

42. Contact N3 closes, and, G2 being closed, relay R42(L) at the manual exchange energises.

43. Contact L1 operates and glows the calling lamp L43.

44. When relay P(R23, circuit 40) operated, ringing current was applied to the A and B wires and ringing tone transmitted to the caller. The ringing current, however, is not employed to call the desired station, and is prevented from doing so by contacts TS2 and TS3. Ringing tone is transmitted to the caller from the selector.

45. When the manual operator answers, battery from the cord-circuit is connected to the A wire by a cross-over, and relay R45(TS) is operated. Contact TS1 changes over and relay TS is held operated *via* contact N5 to battery.

46. Contacts TS2 and TS3 close and put the connection through.

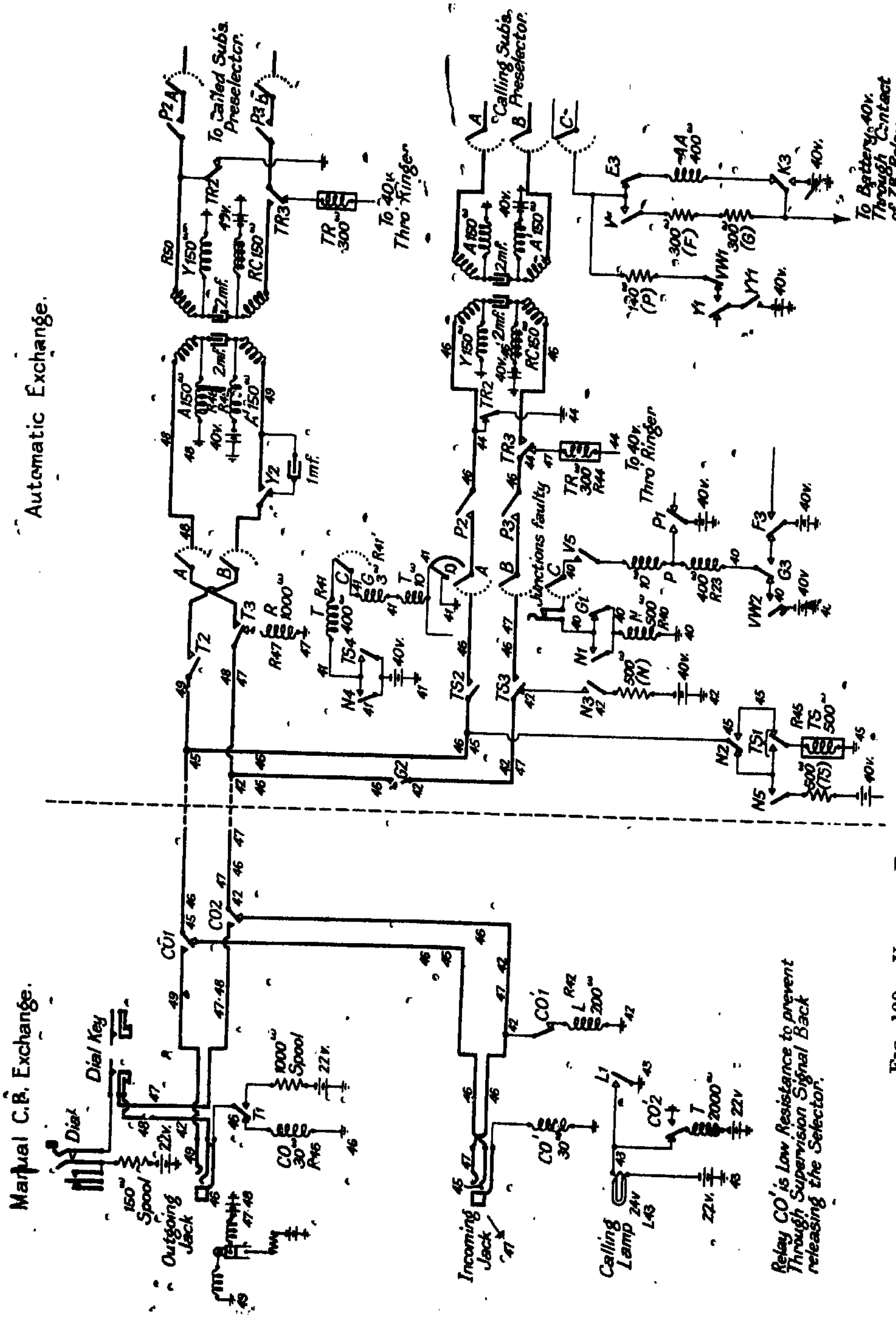


FIG. 109.—VILLAGE EXCHANGE (SIEMENS). BOTHWAY JUNCTION TO C.B. OFFICE.

47. Earth on the B wire operates the tripping relay R44(TR) in the selector circuit. Ringing and ringing tone are disconnected and the circuit is in condition for conversation.

The answering supervisory relay in the manual operator's cord-circuit is energised by the current from the R.C. coil in the selector-circuit.

Release of Connection.—When the automatic subscriber clears, battery is disconnected from the B wire and relay R40(N) is released over the C wire. The removal of battery from the B wire de-energises the supervisory relay in the cord-circuit and gives the clearing signal to the operator.

The release of R40(N) causes relay R45(TS) to be held, through the back contact of N2, dependent on the operator.

Contact N3 (circuit 42) opens, to prevent battery being again connected to the B wire, when TS3 falls back. The preselector T(R41) relay and relay G(R41' circuit 41) are now held dependent only on relay TS.

Contacts N1 and G1 both being open, the junction cannot be picked up again by any other selector until the operator withdraws the plug.

When the operator withdraws the plug, relay R45(TS) is released and releases relays R41(T) and R41'(G). The preselector circuit is thus restored to normal and contact G1 couples up relay R40(N) to the C wire ready for further use.

Setting up the Connection of an Incoming Call from a Manual C.B. Exchange (Fig. 109).

46. Coil R46 energises.

47. When a call is made from the manual C.B. exchange, R47(R) of the junction preselector is operated by battery from the B side of the calling cord-circuit.

48. The preselector switch then searches for a free line and, when this is found, the selector is held by its R48(A) relay being operated by the current over the B wire of the junction, and its R49A' relay operated over the A wire. Meanwhile, relay R41(T) at the automatic exchange has operated and cut the drive, relay G is operated in series with relay R41'(T), and at contact G1 opens the circuit 40 of relay R40(N), so that the junction cannot be picked up by an outgoing call.

The dialling signal is transmitted to the calling operator over the A and B wires.

The dialling key in the junction when operated replaces the battery from the cord-circuit by battery through the dial contacts. The operation of the dial then controls the selector, connection with the required subscriber is made in the usual manner, and the ringing tone is transmitted to the operator when the dialling key is returned to normal. When the automatic subscriber replies, the operation of R50(Y) operates Y2 in the B wire of the selector, and thus connects battery over the A wire (circuit 49) of the junction to the supervisory relay in the calling-cord circuit.

Release of connection from automatic subscriber.

When the called subscriber clears, the back release operation of the selector causes it to return to normal and release the calling junction preselector. The junction preselector then picks up another disengaged selector, which, since its Y relay is unoperated, will not connect battery to the junction. The calling supervisory lamp in the operator's cord-circuit will thus glow.

If a junction in one group is called by a junction in another group, then the operation of Y2 (circuit 49) will provide for the transmission of a through signal between the two manual exchanges. The supervisory signal at the outgoing exchange will cease to glow when the distant exchange answers and will glow should the distant exchange clear first. This signal cannot be made dependent on the called manual subscriber, since, if this subscriber flashed his switchhook, the back release function of the selector would cause the connection to be released. For this reason the sleeve relay on the incoming jack is made of low resistance instead of the usual high resistance, thus allowing the marginal sleeve relay in the manual cord-circuit to operate and connect battery to the B wire of the junction, immediately the plug is inserted.

This facility also enables one junction in a group to be tested from the manual exchange by calling another junction in the same group, and thus returning the call to the originating exchange. In connection with this facility, it is possible to return the call made over a particular junction in the group, by dialling the number of the contact on the level to which that junction is connected.

Release of connection by manual operator on incoming call from manual exchange.

When the operator withdraws the plug, the selector and preselector circuits are released. Hence relays R41(T) and R41′(G) are released and the bothway junction circuit is returned to normal.

Operation of Bothway Junction to Central Battery Signalling (C.B.S.) Exchange (Fig. 110).—The operation to a C.B.S. exchange is exactly similar as to a C.B. exchange, as far as the automatic exchange is concerned. The automatic end of the junction is similar to Fig. 109.

The auxiliary apparatus for the junction fitted at the manual end is the same as would be fitted at a C.B.S. exchange, to allow of working to a manual C.B. exchange.

The calling indicator in the C.B.S. exchange is operated by the energising of relay LR from battery over the B wire of the junction. When the calling line clears, relay LR is released, and contact LR1 falling back connects earth to the tip of the cord-circuit, thus operating the clearing indicator.

The transmission of the called exchange supervisory signal back to the automatic exchange for re-transmission to the originating manual exchange, should the call have been originated over a junction in another group, is provided by the connection of battery to the A wire of the junction through N200, R1, and the extra springs on the incoming jack.

Since it is not possible to transmit a supervisory signal from the called line back through the automatic equipment (see under C.B. junction), the relay usually connected to the bush of the incoming jack must be disconnected so that the battery through N200 is not removed from the A wire by the operation of R1.

Operation of Bothway Junction to Magneto Exchange (without Supervisory Signal at Magneto Outgoing).—The magneto circuit with supervision is based on the same principle as the C.B.S. circuit, the magneto conditions being transformed to C.B. conditions by the same auxiliary equipment as used between a magneto and a manual C.B. exchange. The connections at the manual office are shown in Fig. 111, the automatic being exactly as shown for C.B. in Fig. 109.

The calling indicator is energised by the operation of relay LR by battery over the B wire of the junction.

The clear from the calling automatic subscriber is received on the calling indicator by the release of LR1. Should the operator clear the connection on the dropping of the clearing indicator in the cord-circuit, before the automatic subscriber has cleared, then relay NR is still held, over contact LR1 in the operated position, and the calling indicator does not then

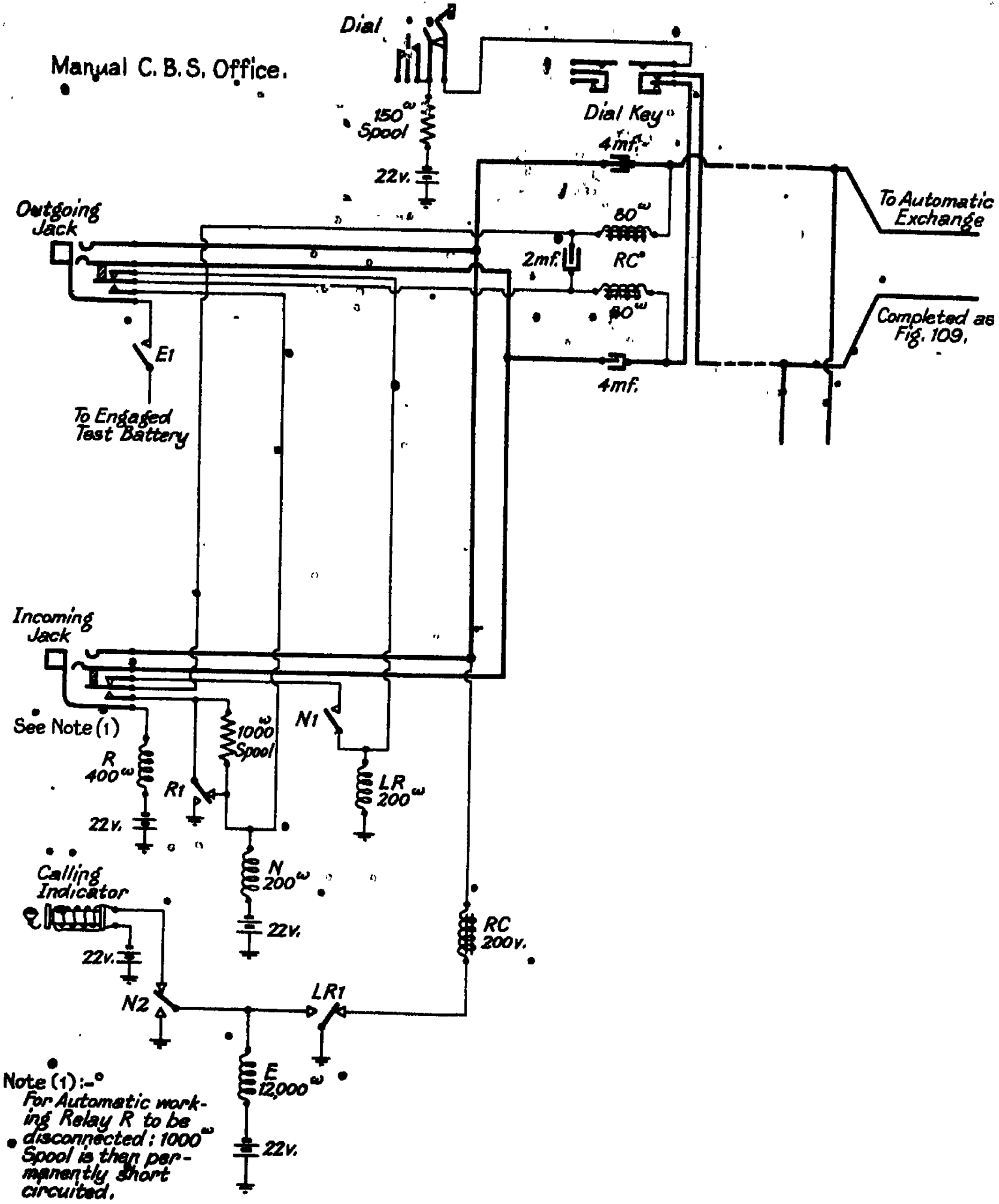
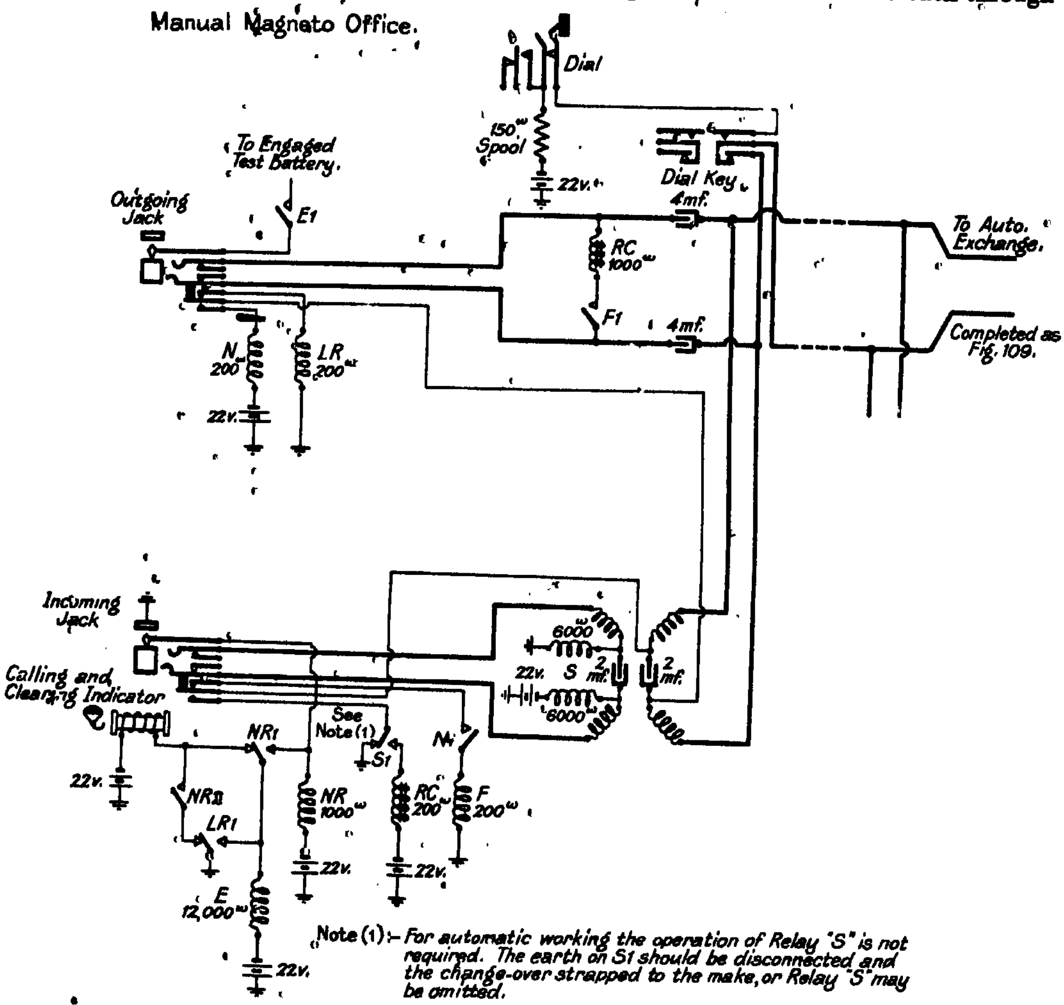


FIG. 110.—VILLAGE AUTOMATIC EXCHANGE (SIEMENS). BOTHWAY C.B.S. JUNCTION.

come into use as a clearing signal at all, since, if it were to do so, it would probably be mistaken for another call.

It not being possible to transmit a supervisory signal from the called line back through

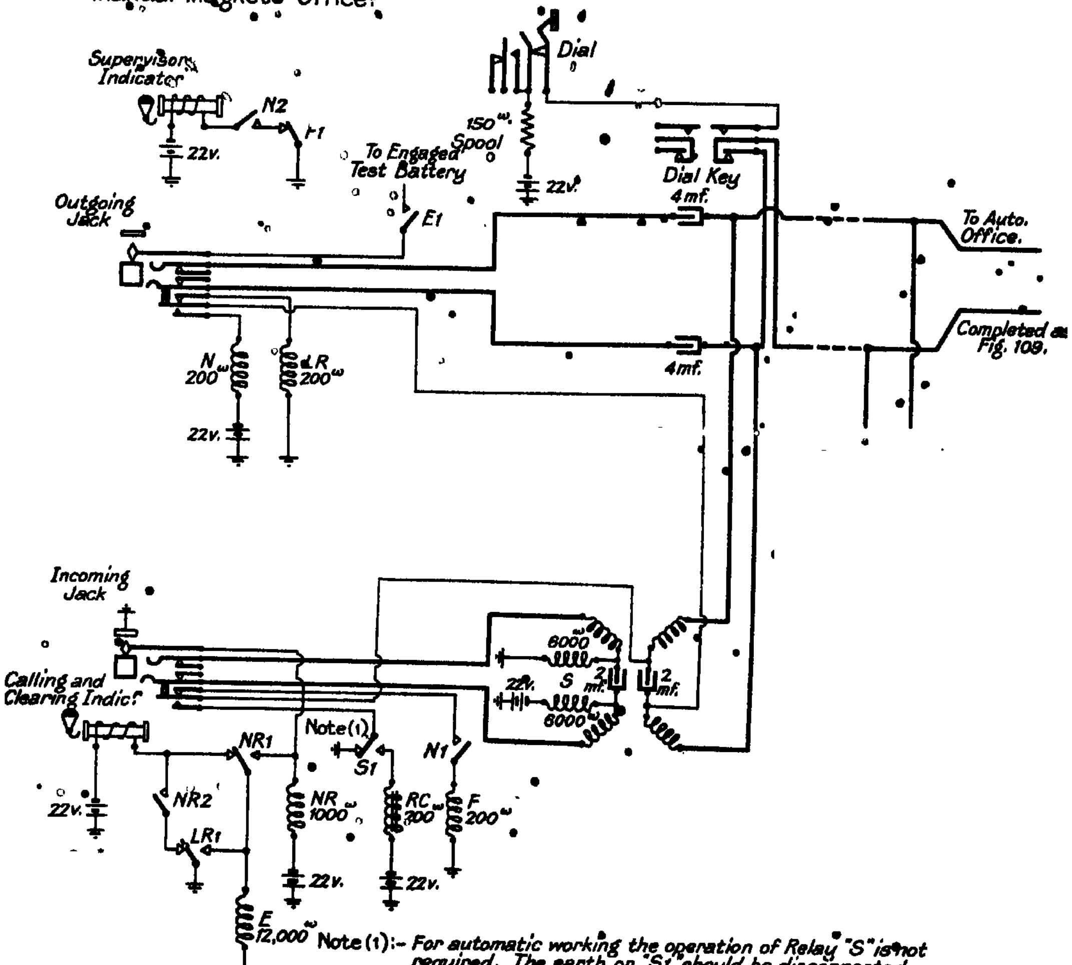


Note (1):- For automatic working the operation of Relay "S" is not required. The earth on S1 should be disconnected and the change-over strapped to the make, or Relay "S" may be omitted.

FIG. 111.—VILLAGE EXCHANGE (SIEMENS). BOTHWAY JUNCTION TO MAGNETO OFFICE. NO SUPERVISORY SIGNAL IN OUTGOING CIRCUIT.

the automatic equipment (see under C.B. junction), it is necessary to modify the usual junction auxiliary apparatus at the magneto end by cutting out contact S1, or omitting the relay altogether, and thus making the connection of battery to the A wire of the junction dependent only on the insertion of the plug in the incoming jack.

The outgoing junction circuit is arranged to transmit the supervisory signal from the automatic through to an exchange whose access to the automatic exchange is gained through the magneto office. A contact on relay F completes the loop through a retard coil and operates the supervisory signal at the originating exchange.



Note (1):- For automatic working the operation of Relay "S" is not required. The earth on "S1" should be disconnected and the change-over strapped to the make. Relay "S" may be omitted.

FIG. 112.—VILLAGE EXCHANGE (SIEMENS) BOTHWAY JUNCTION TO MAGNETO OFFICE. SUPERVISORY SIGNAL IN OUTGOING CIRCUIT.

Operation of Bothway Junction to Magneto Exchange (with Supervisory Signal on Outgoing at Magneto).—Fig 112 shows the circuit at the magneto office, the automatic being as shown in Fig 109.

A supervisory signal is fitted on the outgoing circuit which is controlled by relay F, which in turn receives the supervisory signal from the automatic exchange. In this instance there is no through signalling arranged.

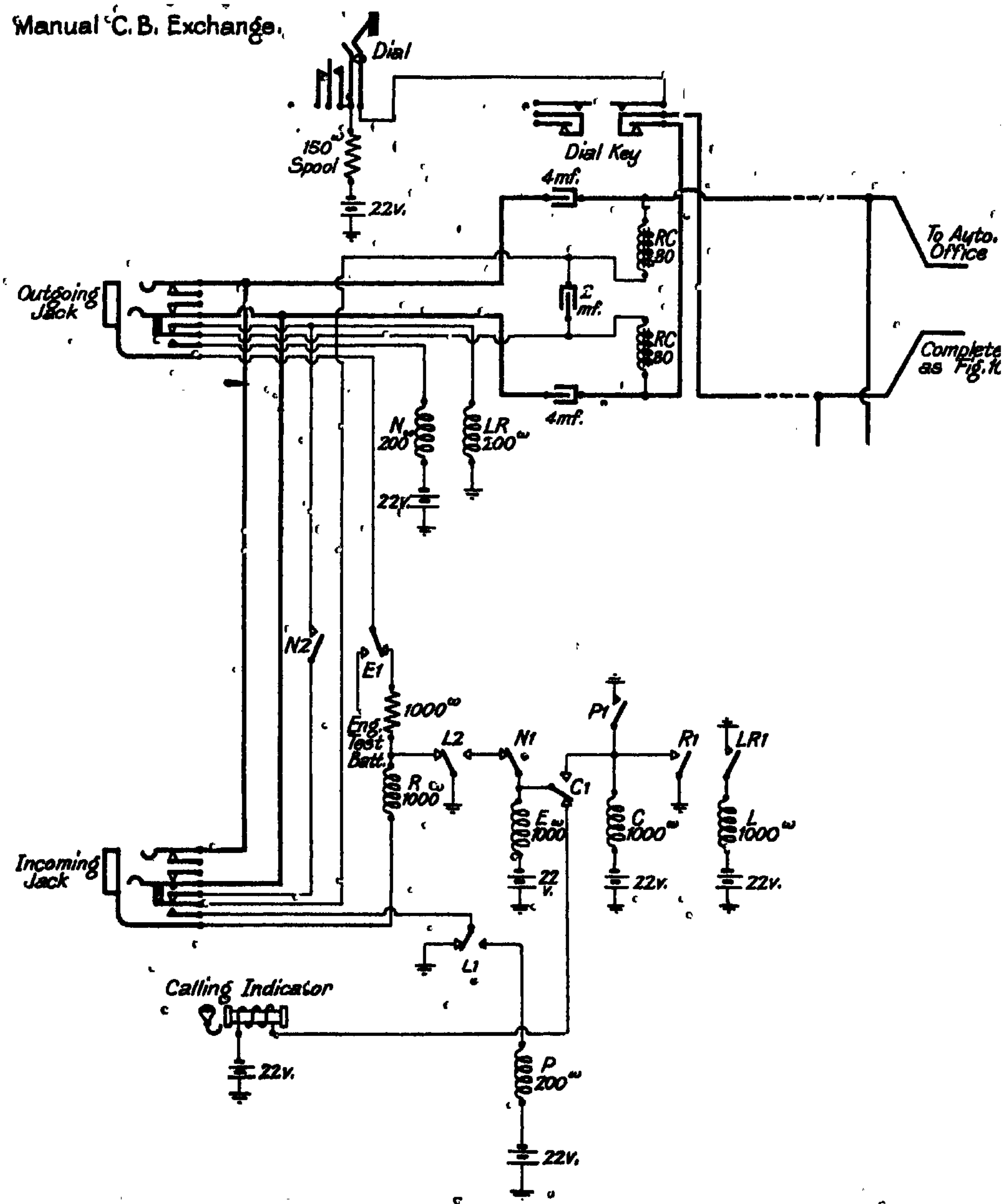


FIG. 113.—VILLAGE EXCHANGE (SIEMENS) BOTHWAY JUNCTION TO TRUNK OFFICE.

Operation of Bothway Junction to Trunk Exchange.—Fig. 113 shows connections at the trunk exchange, the automatic being as Fig. 109.

The operation of this circuit, as far as calls to and from the automatic exchange are concerned, is the same in principle as the circuit to the C.B.S. exchange.

The P relay must be connected directly to the auxiliary make spring on the incoming jack, so that battery is always connected to the A wire of the junction whilst the plug is in the jack.

Party-Line Working (Fig. 114).—Sub-stations on a party line are called by means of a code system of ringing.

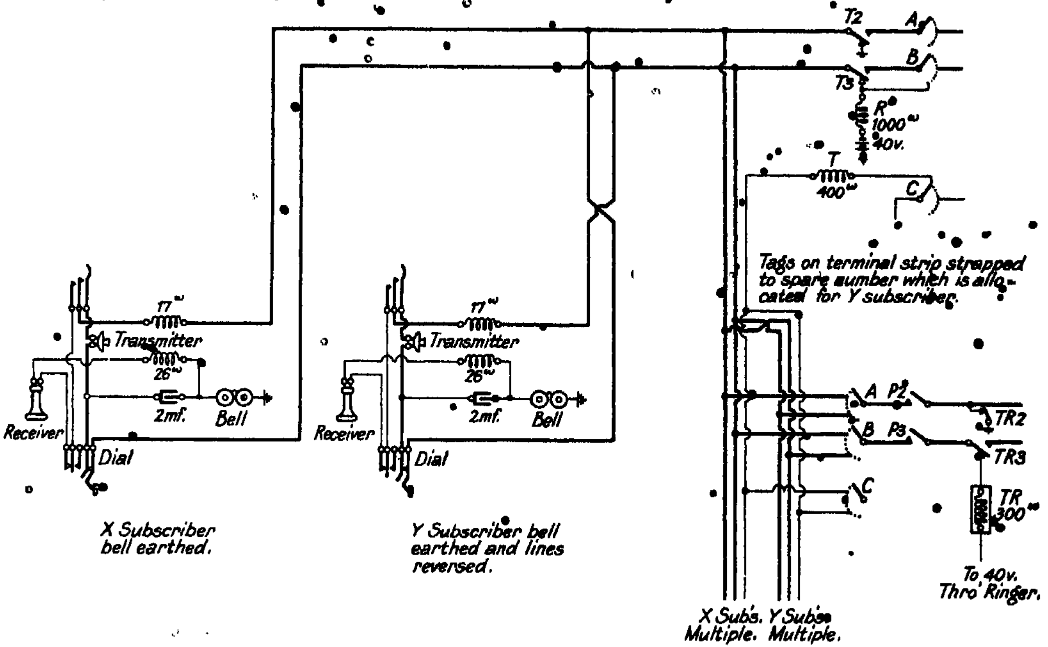


FIG. 114.—VILLAGE AUTOMATIC EXCHANGE (SIEMENS). PARTY-LINE WORKING.

These codes consist of a combination of short and long rings.

Each subscriber on the party line has a separate number on the automatic equipment, but there is only one preselector switch required for each party line.

Whenever a call is made to any one of the subscribers on a party line, a long preliminary ring is given on each subscriber's bell, and then the code of the subscriber required is sent out.

The ringing on all the bells ceases immediately the called subscriber answers.

When it is required to connect two subscribers on a party line, the multiple wires corresponding to the numbers of their respective instruments are strapped together on the terminal block at the side of the rack. The A and B wires in the strap between the multiple wires are crossed. The bells of both instruments on the party line are connected to earth, and the A and B wires on the Y subscriber's instrument are reversed as usual. It is necessary to increase the tension of the bias spring of each bell considerably, to prevent the bell of one instrument from operating when dialling is taking place at the other instrument.

The Petrol-Electric System of Charging.—This power plant consists of a generator, driven by a petrol engine, with automatic controlling instruments and apparatus, and two 40-volt batteries.

The exchange is connected to the batteries alternately for 24-hour periods. As each battery is disconnected from the exchange it is automatically connected to the petrol-electric set until it is fully charged.

The changing over of the batteries is done by a motor-driven switch. This switch, in the first place, connects the idle battery to the exchange and disconnects the discharged battery; secondly, connects the discharged battery to the generator of the petrol-electric set in its starting condition; and, thirdly, changes the circuit of the petrol-electric set to the running and charging condition. These conditions are then maintained until the battery is fully charged.

The starting of the motor switch is controlled by a time switch, which can be set to operate at any time of the day.

When the voltage of the battery on charge reaches the maximum charge voltage, a voltmeter contact again starts the switch motor. The switch now disconnects the battery on charge and stops the petrol-electric set.

If it is not desired to start the petrol engine automatically, arrangements can be made for the generating set to be started by hand, either from the battery or by a starting handle.

The set may also be stopped by hand, but as it would not be necessary for an attendant to remain with the set during the charging period, the engine may be stopped automatically by means of an instrument such as a time switch, voltmeter, or ampere-hour meter.

The Petrol-Electric Set.—The petrol-electric set, which has an output of approximately ·75 k.w., is of the type shown in Fig. 119. The engine, which is air-cooled by means of a fan incorporated in the flywheel, is fitted with overhead valves. Coil ignition is employed.

The generator is shunt-wound, but equipped with a special series field which is only in circuit when the set is starting up.

The engine and generator are direct-coupled.

The Alarm System.—Alarms are provided to draw attention to a permanent loop, switch magnet under permanent current, failure of ringing, blown fuse, and failure of charging set. As these equipments may be absolutely unattended, it has been necessary to decide which faults call for early attention and which may be left until it is convenient to attend to them. It has been decided that a permanent loop, apart from the inconvenience to the subscriber, does not require urgent attention, but the other faults should be cleared as quickly as possible.

The method of distinguishing between an urgent or non-urgent fault is as follows:—When the alarm bell rings (this bell may be placed wherever desired by the official responsible for the exchange) the alarm switch is thrown. If the fault requires urgent attention, the bell will cease to ring continuously, but will ring for a few seconds at periods of 2¾ minutes. It is therefore impossible for an urgent fault to be forgotten when the alarm switch is operated.

If the fault is non-urgent, then, when the alarm switch is thrown, the bell will cease to ring entirely.

An alternative arrangement can be provided for an unattended exchange by which the alarm signal is given over a junction to an operator in the main exchange. The operator can then determine whether the fault is urgent or non-urgent.

Further, the operator can, at any time, by calling a certain number, test whether or not the automatic exchange is free from faults.

A special feature of this equipment is the method of disconnecting faulty lines, which set up the permanent loop alarm condition from the equipment.

When a preselector engages a selector, either through the receiver being lifted or through the line becoming looped by a fault, a time-lag circuit comes into operation. If impulses are sent within a period of 2$\frac{3}{4}$ minutes, this circuit does not complete its operation, but if impulses are not sent within this time, as would be the case when the line is looped through a fault, the holding circuit of the preselector is broken and the preselector drives to the tenth contact where it is held by another circuit until the fault is cleared. At this point the alarm bell is rung.

By this means selectors cannot be held engaged, and the number of available switching circuits reduced by faulty lines.

Section 54

VILLAGE EXCHANGE COMMON APPARATUS CIRCUITS (SIEMENS)

The common apparatus and alarm circuits (Fig. 115) are concerned chiefly with the supply and control of the ringing, tone and driving currents required by the automatic equipment and with the control of the various alarm circuits which come into operation when attention is required.

The ringing current, and tone current, is supplied from a small dynamotor which also drives cams performing various functions. The tone current is derived from especially wound interpoles mounted on the machine (see Fig. 93A).

The current for driving the preselectors and selectors is interrupted by contacts operated by cams driven directly by the dynamotor shaft. The contacts interrupting the current for the preselector drive are operated by a double-throw cam which gives a speed of about 35 interruptions per second. The contacts for the selector drive are operated by a single-throw cam giving about 17 interruptions per second.

Each interrupter contact is provided with a relay, which prevents a switch driving magnet being subjected to continuous current should the interrupter contact become short-circuited. This relay will function similarly if the interrupter fails to run, or if it stops while a switch is being driven.

A third cam, driven direct from the dynamotor shaft, is used to supply the current used for dialling and ringing signals. This current is of a comparatively low frequency, and is obtained by the charge and discharge of a condenser through two windings which form the primary of a transformer. This method avoids the possibility of a continuous current flowing when the machine is stationary.

The ringing, ringing signal, and busy tone interrupters are cam-operated contacts which are driven through reduction gearing from the dynamotor shaft.

Two cams associated with the alarm system, and a cam used to control the running of the machine itself, are also driven through suitable reduction gearing.

The circuits are so arranged that the machine is normally at rest, but starts running when a call is made. When started, the machine is arranged to run for a period of about 2½ minutes, after which, if no further call is made, it automatically stops. This period is sufficient for the making and answering of an ordinary call. At the end of the 2½ minutes' period, the ringing current will be cut off; but it can, of course, be started again by clearing and calling the required number again. It is not necessary for the machine to be running during the period of conversation, so that the duration of the call is not confined to the 2½ minutes' period. Should another call be made while the machine is already running, then the control circuit will cause the motor generator to run for at least 2½ minutes after the second call has been made.

A switch is provided by which the control circuit may be disconnected and the machine run continuously.

Alarms are given for the following conditions of failure :—

1. Line faults, such as a loop or a B wire earth, causing a selector to be picked up (Permanent loop alarm).
2. Permanent current on switch magnets.
3. Failure of ringing supply.

4. Fuse blown.

5. Failure of charging set. (This alarm is associated with the power circuit.)

The permanent loop alarm and the switch magnet alarm are under control of the slow-acting alarm cam, and only come into operation when the fault has existed long enough to allow this cam to make a complete revolution. This is necessary in the case of the permanent loop and switch magnet alarms, since the conditions which bring these into operation only constitute faults when inordinately prolonged.

In conjunction with the permanent loop alarm, a circuit arrangement is provided which will automatically free a selector which has been picked up by a faulty line. The preselector of the faulty line, when released by the selector in such a case, is caused to rotate until it reaches the last contact (10), where it is allowed to test. It is then held in this position until the fault is cleared. It will then automatically return to normal and be ready for further use. The tenth bank contacts of the preselectors are not multiplied, so that any number of preselectors may simultaneously be held in this position.

Faults occurring on an unattended equipment may be divided into two classes: those requiring early attention and those which may be attended to as opportunity offers. A permanent loop or a B wire earth are regarded as non-urgent faults, all other faults are urgent.

When a fault, other than a permanent loop or a B wire earth, occurs on the equipment, a flashing signal, provided by means of a series of slow acting relays, is transmitted over a certain junction to the manual board at the controlling exchange. The fault is then reported by the operator to the maintenance staff responsible for the automatic exchange.

The circuit is associated with one junction only, but the circuit arrangements are such that the alarm signal is not given unless that junction is free. If the junction is engaged when a fault occurs, the alarm circuit is prepared and engages the junction immediately it becomes free after the ordinary call.

Further, if it is desired to test either the automatic exchange for faults, or the junction alarm circuit itself, from the controlling exchange, a call may be originated from the manual board over another junction to a certain test number on the automatic exchange. A tone signal is then transmitted back to the calling operator informing her whether or not there are faults present on the equipment, and consequently whether the junction alarm circuit is operating correctly.

Indication is not given when permanent loop or B wire earth faults occur, as these do not require urgent attention. A switch, which is normally left open, is provided in the permanent loop alarm circuit, and so connected that no indication of permanent loop or B wire earth faults is normally given. When the exchange is visited, the maintenance officer will throw this switch and, if any permanent loop or earth faults exist on the equipment, the PL alarm lamp will glow.

The test number should be preferably No. 19. This number is chosen as it will be the last number on the equipment to be allotted to a subscriber, so that no change of the test number will be necessary until the exchange reaches its full capacity.

Common Circuit Operation (Fig. 115).

Driving Circuit.—Each interrupter contact is provided with a DK relay, which prevents the switch magnets being subjected to a continuous current if the interrupter contact for any reason fails to open or becomes short-circuited. Under normal operation, when a switch is driving, the DK relay is held operated by the current through the driving magnet, which passes through its 2500-ohm winding when the interrupter contact is open. This current is not sufficient to affect the driving magnet, which releases when the contacts are open, as if the circuit had been entirely disconnected. When the interrupter contact is closed, the DK relay is short-circuited, but at the speed the interrupter contact operates, it does not release owing to the eddy currents produced in the short-circuited winding.

Should, however, the interrupter spring become permanently short-circuited, the DK relay will release and, by opening contact DK1, will throw the 1000-ohm resistance on DK into circuit with the driving magnet, so limiting the current which can be drawn, and thus protecting the driving magnet from undue heating.

Ringing and Ringing Interrupter Circuits.—The ringing current is obtained from a winding on the motor armature and is collected by means of slip rings. One side of the ringing winding is connected to battery.

The ringing current is interrupted by a cam-operated contact which connects the ringing winding in series with battery for approximately one second in every 3 seconds, thus ringing the bell of the called telephone intermittently. During the period of 2 seconds between rings, the contact connects the exchange ringing lead direct to the battery, to allow of the tripping relays being operated when a call is answered between the ringing periods.

Dialling and Ringing Signals.—The current of these signals is obtained from a transformer which has two primary coils. The current in these coils is produced by the charge and discharge of a condenser. The action is obtained by means of two interrupter spring sets which are operated by a cam having a ratio of break : make=2 : 1. The interrupter springs are connected up to form a change-over contact with the condenser connected to the common spring.

When one spring closes, the condenser is charged through : battery, condenser, interrupter spring, one primary coil, to earth. This spring now opens and the other spring closes, thus allowing the condenser to discharge through its own local circuit comprising the condenser, interrupter spring, and the other primary coil. The secondary coil is connected through controlling contacts to the B wire in the selector circuit, and tone current returns to earth over the A wire through contact TR2. The secondary coil is shunted by a 100-ohm spool in order to produce a subdued tone.

The dialling signal is continuous, but the ringing signal circuit is interrupted by a cam and spring set of the same type as used to interrupt the ringing current.

Busy and Number Unobtainable Tone and Lamp Flashing Circuits.—The tone required for the busy and number unobtainable signals is obtained from a tone coil wound on special interpoles fitted to the motor and energised in series with the field.

The tone is taken through a condenser to the primary of a transformer, which has two secondary windings. The busy tone is taken from one of these windings and is interrupted by a cam operated spring set. The busy tone is applied to the A wire of the selector and returns to earth over the B wire.

During the tone period the A wire is connected to battery through one coil of the secondary of the tone transformer, while during the silent period it is connected to earth. The Y relay in the selector circuit is thus intermittently operated and gives a lamp-flashing signal back to the cord circuit in the manual exchange, should the call have come over a junction.

The number unobtainable tone for faulty lines is obtained from the same secondary winding as the busy tone, but is not interrupted. The number unobtainable tone for dead numbers is obtained from the other secondary winding of the transformer.

Fuse Alarm Circuit.—The distributing fuses are of the alarm type. When a fuse melts relay FP is energised through battery, alarm bar, 400-ohm spool, FP1·5, to earth. In the case of drive fuses, relay FP is energised by interrupted current, but remains operated during the interruptions of the current.

Contact FP1 closes and glows the fuse alarm pilot lamp and energises relay AB through battery, fuse alarm lamp, FP1, AB 5·0, to earth.

Contact AB1 closes and brings in the apparatus for transmitting the alarm over a junction as already described.

Permanent Loop Alarm Circuit.—This alarm is provided to detect cases of receivers being left off the switch-hook and of line wires becoming short-circuited or earthed. In the case of a permanent loop fault, the selector is engaged in the same way as when a call is made, while in the case of an earth fault on the B wire, relay A1 in the selector circuit is energised over the B wire to the earth fault.

Relay A^1 closes its contact $A^1 1$, which is connected in parallel with contact A1 and the selector is thereby held engaged. The alarm circuit is arranged so that selectors engaged through such faults are automatically released after a certain period.

When a selector is engaged by a preselector, relay PL, which is common to the rack, is energised through battery, P1, V3, 300-ohm (E), PL1·5, to earth.

Contact PL1 closes and prepares the circuit of the slow-alarm relay SB, which is controlled by contacts operated by the slow-alarm cam.

Relay SB operates when the cam contacts close on the high position of the cam. Contact SB1 operates and closes a holding circuit for relay SB.

Contact SB2 closes and prepares the circuit of the other slow-alarm relay ZB1, which operates when the cam contacts close on the low position of the cam. The operation of ZB1 also operates relays ZB2 and ZB3.

Each selector has a ZB contact associated with it. When a preselector engages a selector, the T relay of the preselector is energised by battery through the ZB contact. If the selector has been engaged by a subscriber, then immediately the impulses are sent, contact K3 is operated and the preselector T relay is then independent on the ZB contact. If, however, the selector has been engaged by a fault, no impulses will be received and the preselector T relay remains dependent upon the ZB contact. When, after one revolution of the slow-alarm cam, the ZB relays operate, a preselector which is dependent upon a ZB contact will be released.

When relay ZB3 operates, contact $ZB3^1$ prepares a testing circuit, for the preselector T relay, on the tenth choice of the preselector bank.

When the preselector is released from the selector by the ZB contact opening, it drives to the tenth choice. Relay T is then energised through $ZB3^1$, P 1·5, 500-ohm (R), R3, C wiper arm, T10+400, R1, to earth. The preselector cannot test on any other free selector when it is driving to the tenth choice, as the ZB relays remain operated long enough for it to reach this contact.

Relay P operates when the preselector engages the tenth choice.

Contact P1 operates and completes a holding circuit for relay P and the preselector T relay.

When the selector is released, relay P1 is released and, in consequence, relays SB and ZB release.

When the P1 switch, which is normally left on open circuit, is closed, the permanent loop alarm pilot lamp lights when ZB3 has operated, and remains alight through battery, P1, PL lamp, P1 switch, AB 5·0, to earth. Relay AB operates.

Contact AB1 closes, and brings in the apparatus for transmitting the alarm over a junction.

The disconnecting and alarming operations are thus delayed until the slow-acting alarm cam has made at least one revolution. During this time the whole sequence is dependent upon relay PL holding relay SB, so that, should dialling take place and relay PL be released before the cam has made its complete revolution, as would happen on an ordinary call, no alarm will be given.

The preselector wiper arms remain on the tenth choice until the fault is cleared, when the preselector R relay is released.

Contact R3 opens releasing relays T and P, and the alarm signals cease. The preselector drives to normal as when an ordinary call is cleared.

Magnet Alarm Circuit.—This alarm is provided to draw attention to a switch magnet becoming permanently energised. This may occur due to the failure of a selector to release, in which case the release magnet would be held permanently energised, by contact K2 failing to open the circuit. Or again, the failure of a preselector to drive to normal properly would result in its driving magnet being permanently energised.

When any switch is brought into use, its operating current passes through a magnet alarm relay MA. Relay MA operates and prepares the circuit of the slow-alarm relay SA, which is controlled by contacts operated by the slow-alarm cam. Relay SA operates when the cam contacts close on the high position of the cam.

Contact SA1 operates and closes a holding circuit for relay SA.

Contact SA2 closes and prepares the circuit of the other slow-alarm relay ZA, which operates when the cam contacts close on the low position of the cam.

Contact ZA1 operates and closes a holding circuit for relay ZA.

Contact ZA2 closes and completes the circuit of the MA pilot lamp and relay AB through battery, A pilot lamp, ZA2, AB 5·0, to earth. Relay AB operates.

Contact AB1 closes and brings in the apparatus for transmitting the alarm over a junction.

The operation of the alarm is thus delayed until the slow-acting alarm cam has made at least one revolution. During this time the whole sequence is dependent upon relay MA holding relay SA, so that should the fault be cleared and relay MA be released before the cam has made its complete revolution, no alarm will be given.

Ringing Failure Alarm.—This alarm is provided to draw attention to a failure of the ringing current. Relay RG, which is connected to the inner ringing interrupter contact, is permanently energised through the ringing winding, RG1000, to earth.

If the ringing circuit becomes disconnected at any point, relay RG releases and, at contact RG1, closes the circuit of the RG pilot lamp and relay AB through battery, RG pilot lamp, RG1, AB 5·0, to earth. Relay AB operates, contact AB1 closes, and introduces the apparatus for transmitting the alarm over a junction.

Motor and Fault Alarm Control Circuit.—For all purposes, other than testing, the motor switch will be in the normal position, which means that the motor will be normally stopped, and will commence to run directly a call is made.

The starting circuit is brought into operation by the closing of the preselector driving magnet circuit through battery, DA 1000, DS 1·5, 1000-ohm (DK), DK 2500, or interrupter spring (if closed), MA 1·5 driving magnet, T1, R2, to earth. Relay DA operates.

Contact DA1 closes and operates relay DV through battery DV500, DA1, to earth.

Contact DV1 operates and closes the circuit of relay NS, through battery, NS 1000, DV1, to earth.

Contact DV2 connects the two 1·2 amp. motor fuses in parallel while the motor is starting.

Relay NS having operated, contact NS1 closes the circuit of the motor in series with NS 5·0.

Contact NS2 short-circuits relay DA, and driving current for the preselector is connected to the interrupter spring through contact NS2.

While the preselector is driving, relay DS is operated. Contact DS1 closes a holding circuit for NS 1000.

Contact NS1 having operated, relay NS is held energised in series with the motor by its 5-ohm coil. Relay NS is therefore not dependent on contact DS1, and will not release when the preselector completes its drive and relay DS releases.

The motor control cam now operates the motor control spring set; which, on closing its first contact, makes the motor circuit independent of NS1 ; and on closing its second contact, short circuits NS 5·0, allowing relay NS to release unless still held by relay DS.

The control spring set remains in this condition, with both contacts closed, for about a quarter of a minute, the cam then allows the last made contact to open, but keeps the early closing contact closed.

The motor circuit then remains completed through the early closing control contact and the back contact of NS1, until the control cam reaches its normal position, when the early closing contact of the spring set opens the motor circuit.

Should a further call be made while the motor is running, and both control contacts closed, then the closing of the second driving magnet circuit again operates relays DA, DV, and NS, as before, to connect battery to the interrupter spring.

Should a further call be made while the motor is running, but after the late closing contact has opened, then the closing of the driving magnet circuit, as before, operates relays DA, DV, and NS, but, as the late closing contact is now open, contact NS1 having changed over, will hold relay NS operated after relays DV and DS have released, the motor now running again in series with NS 5·0. When the control cam reaches the normal position, and both control contacts open, the motor circuit will in this case still be maintained through NS 5·0 and contact NS1 : the motor will therefore continue to run and will drive the control cam through another revolution. The control cam then proceeds to close both contacts and to release relay NS by short-circuiting its 5-ohm winding, as before described.

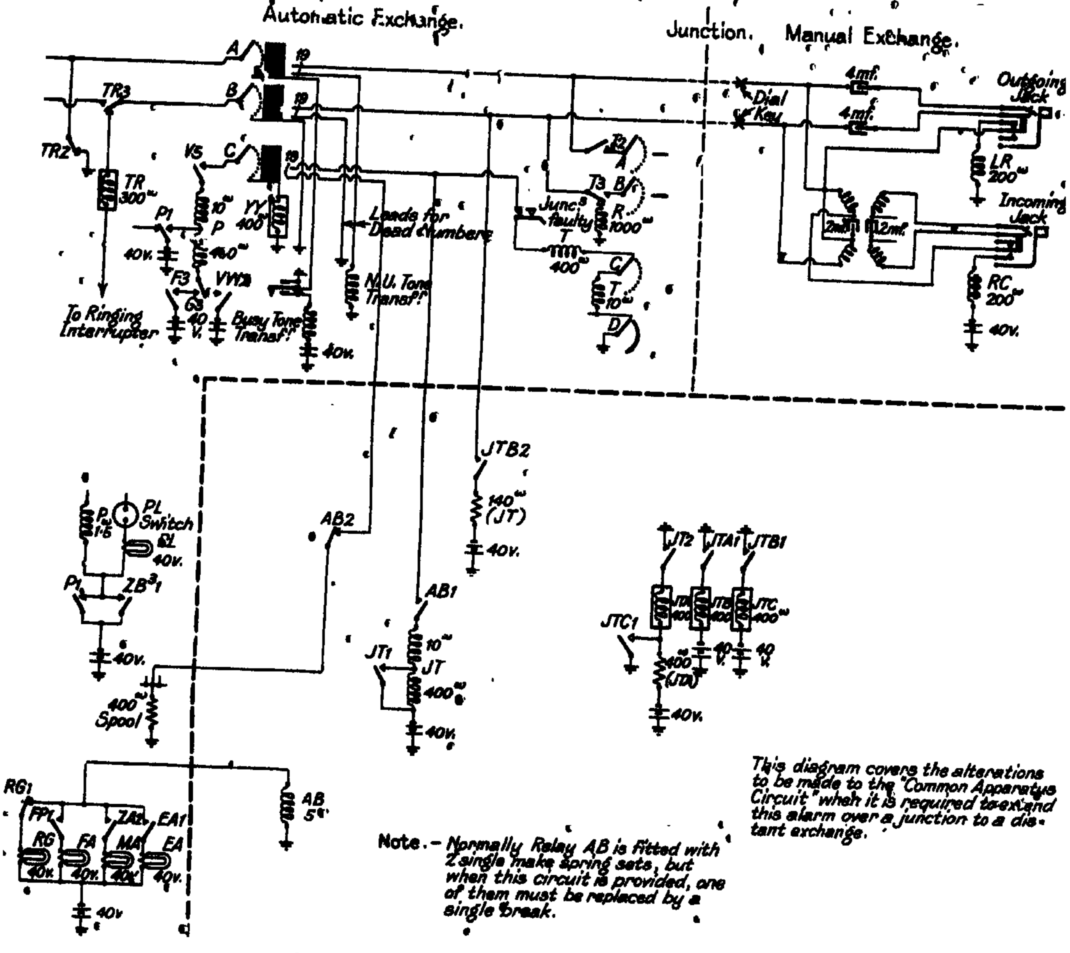
The motor is now again under control of the early-closing contact only, and when the cam again reaches normal, the contact opens and the motor is brought to rest.

It will be seen from the above that the motor must run for at least 2¼ minutes, less the quarter-minute period during which both contacts are closed, after the last call has been made. Any demand for driving current, as for instance during the release of a connection, or when a preselector is moved from normal by hand, will bring about the same cycle of operations.

The demand for driving current to drive the selector round to the busy contact will, in all ordinary cases, fall within the quarter-minute period, and so will not cause the motor to run through a second revolution of the control cam.

In order to ensure that the dynamotor shall run for a sufficient time to bring in the slow alarm should a fault occur, the motor control cam is set in a definite relation to the slow alarm cam, both of which are mounted on the same shaft.

The relation between the motor control cam and the slow alarm is such that the spring set of the slow-alarm cam, when operated in the high position, is not released from this position until after the late-closing motor control contact has opened, and it closes in the low position before the early-closing motor control contact opens. Thus the slow-alarm relays will be operated and bring in relay AB, which closes contact AB1, to introduce the apparatus for transmitting an alarm over a junction.



This diagram covers the alterations to be made to the "Common Apparatus Circuit" when it is required to extend this alarm over a junction to a distant exchange.

Note.—Normally Relay AB is fitted with 2 single make spring sets, but when this circuit is provided, one of them must be replaced by a single break.

FIG. 116.—VILLAGE EXCHANGE (SIEMENS). JUNCTION ALARM CIRCUIT.

Transmitting the Alarm Signal over a Junction (Fig. 116).—When a fault, except a permanent loop or a B-wire earth, occurs on the equipment, relay AB is energised in series with the alarm lamp associated with the particular fault which has occurred.

Contact AB1 closes and relay JT is connected to the 400-ohm coil of the T relay of the preselector of the particular junction circuit which is used for transmitting the alarm signal.

Relay JT is of the same type as the testing relay P in the selector circuit, and if the junction is free it will operate immediately.

Should the junction be engaged, its T relay circuit is either disconnected—when engaged on an incoming call from the manual exchange, or is at battery potential—when engaged on an outgoing call to the manual exchange. In either case, relay JT will not operate until the junction becomes free.

When relay JT is energised, contact JT1 operates. Relay G then operates and the junction is made busy by the opening of contact G1 to calling selectors.

Contact JT2 closes and relay JTA is energised over :—Battery, 400 ohm (JTA), JTA400, contact JT2 to earth.

When relay JTA is operated :—Contact JTA1 closes and relay JTB is energised.

Contact JTB1 closes and relay JTC is energised.

Contact JTB2 closes and connects battery through 140 ohms (JT) to the B wire of the junction. Relay LR at the manual exchange end of the junction is then energised over :—Battery, 140 ohm (JT), JTB2, B wire, outgoing jack, LR200 to earth.

Relay LR operates the calling signal.

When relay JTC operates, contact JTC1 closes a short-circuit across relay JTA, which releases. The three relays JTA, JTB, and JTC are fitted with copper sleeves and are therefore slow in releasing.

When relay JTA releases, contact JTA1 opens, and relay JTB is released after a short interval. Contact JTB1 opens the circuit of relay JTC, and contact JTB2 opens the circuit of relay LR. Relay LR releases and the calling signal is restored to normal.

Relay JTC releases and the short-circuit is removed from relay JTA at contact JTC1.

Relay JTA immediately operates and the above cycle of operations is repeated.

The circuit remains in operation so long as relay AB is operated, and an intermittent calling signal is thus given at the controlling exchange.

Test from Manual Exchange.—When it is desired to test the automatic equipment for urgent faults from the manual exchange, the operator calls the special test number.

Normally this number will not be used for a subscriber's line until the full capacity of the exchange is reached, and will therefore be connected to the number unobtainable tone circuit.

In the case of this particular number, however, a break contact of relay AB, contact AB2, is placed in series with the C wire to the N.U. tone circuit. The operation is in this case as follows :—

When the equipment is free from urgent faults, relay AB is not operated, and on calling 19 the operator receives the number unobtainable tone signal.

When an urgent fault exists on the equipment, relay AB is operated and the testing circuit for relay P in the selector circuit is opened at contact AB2.

In this case, on reaching contact 19, the testing selector P relay cannot operate and the selector wipers are automatically stepped on to the last contact of the level. The busy signal is then transmitted back to the calling operator.

If the calling operator receives number unobtainable tone, the automatic equipment is clear of urgent faults, but if busy tone is received, it is an indication that an urgent fault has occurred on the equipment. This constitutes a test for the presence of urgent faults, and also automatically tests the junction alarm circuit, because whenever the operator receives busy tone in making the above test, the calling indicator associated with the particular junction used for transmitting the alarm, should be flashing.

Permanent Loop and B-wire Earth Faults.—As permanent loop and B-wire earth faults do not require urgent attention, no alarm is given when they occur. Upon visiting the exchange the maintenance officer throws the switch in the PL alarm lamp circuit. If the lamp glows, permanent loop or B-wire earth faults are present on the equipment. but if the lamp does not glow, the equipment is free from such faults.

Section 55

VILLAGE EXCHANGE ROUTINE-TESTER CIRCUIT (Fig. 117).

The automatic equipment should be carefully and regularly routine-tested in order that conditions which will cause faults shall be located before any trouble results on the equipment.

A test jack is provided on each selector for routine test purposes.

A break jack, through which the multiple of number ninety-nine (99) is wired, is provided to enable tests to be made to this number without disturbing the telephone connected to it, should there be one.

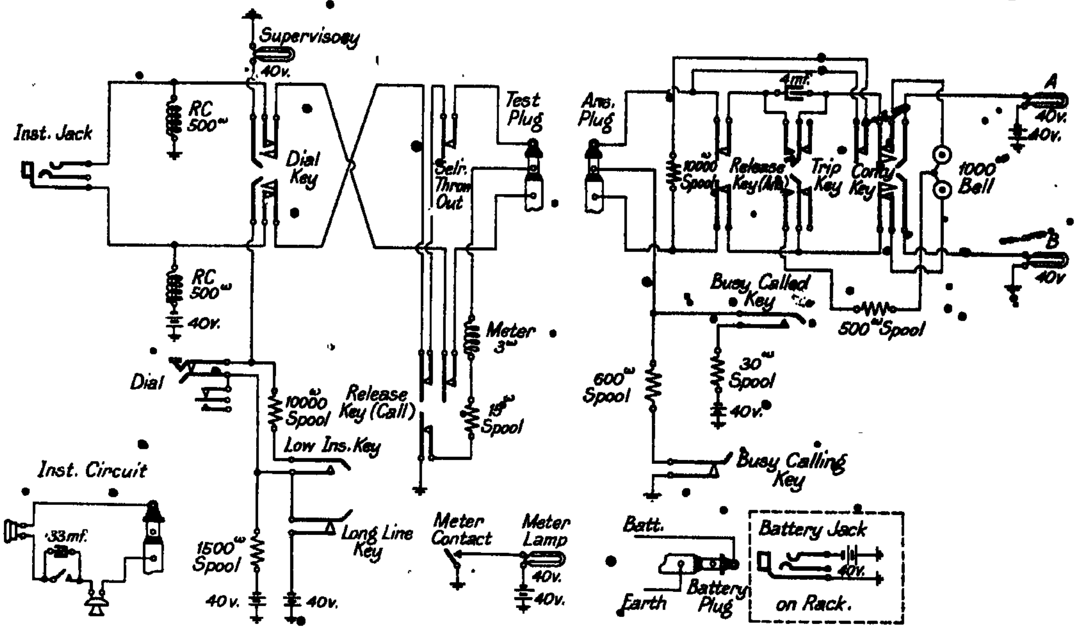


FIG. 117.—VILLAGE EXCHANGE (SIEMENS). ROUTINE-TESTER CIRCUIT.

A battery jack is fitted on the selector rack by means of which battery and earth can be connected to the routine tester.

The conditions reproduced in the routine tester are more severe than would exist in normal working, and therefore, if the circuits pass the tests applied, the ordinary working variations should have no effect on the reliability of the service.

The dialling circuit used in the routine tester is similar to that when the selector is operated from another exchange. The test is then more severe than when dialling from an ordinary subscriber's loop, and if the selector operates satisfactorily under the conditions of the routine tester, it will operate satisfactorily on a subscriber's line with the long line and low insulation conditions under which the system is designed to operate.

Routine Tester, Circuit Operation, and Method of carrying out Tests (Fig. 117).

—Insert battery plug of routine tester into battery jack on the selector rack. Insert answering plug of routine tester into the "99" jack. Connect hand telephone to routine tester.

Now insert the test plug of routine tester into the test jack of the selector to be tested. The selector A relay is operated and the circuit brought into use as if picked up by a junction or a preselector. The selector is engaged by the earth put on the C wire through meter, 15-ohm spool, and calling release key.

Listen on the receiver of the hand telephone, when dialling tone should be heard, proving that the selector transmits dialling tone correctly. This also proves the repeating coil transmission circuit.

By dialling 99 a call can be set up through the selector under test to the answering cord of the routine tester.

Proceed to make the test as follows :—Throw the dialling key and dial 99. The selector should operate in the ordinary way and extend the call to test number and back to the routine tester. Relay P on the selector will operate through 600-ohm spool, busy calling key to earth.

The bell on the routine tester should now ring.

Restore the dialling key and listen for ringing signal in the receiver of the hand telephone.

Throw the tripping key. The selector TR relay should operate and disconnect ringing from the called line. Relay Y on the selector should operate over the loop closed by the trip key and cause the meter to operate. The meter contact glows the meter lamp, which, glowing steadily, indicates the meter is held operated. This proves that the bell will be rung satisfactorily over a line having insulation as low as 10,000 ohms. It also proves metering and that current is being supplied to the called line.

Should the meter lamp, however, not glow, throw the continuity key, when the continuity of the A and B wires from the selector would be proved by lamps A and B glowing.

Listen on the receiver to prove that the ringing signal has been disconnected. While still listening shake the selector cord slightly to prove that no intermittent disconnection exists.

Momentarily throw the answering release key. This disconnects the called loop, and by de-energising the selector Y relay should release the connection. Restore all keys to normal. This proves that release is effected on lines with insulation resistance down to 10,000 ohms.

Now throw the selector throw-out key. This should cause the AA, V, and E relays to operate and release in turn, as long as the key is held operated. This test proves that the selector cannot be picked up by any preselector if the A or B wire is disconnected.

Throw the long line and busy calling keys. Now throw dial key and again dial 99. The bell should not ring, but the switch should drive on to the last contact, and the supervisory lamp should flash. This proves that the selector will operate when connected to a long line, and it will not enter a line engaged on an outgoing call, but will drive on to the last contact and give busy conditions.

Restore the dialling key and listen on the receiver of the hand telephone for interrupted busy tone.

Momentarily throw the calling release key. This disconnects the calling loop and the selector should return to normal. Restore all keys to normal.

Throw the low insulation and busy called keys. Throw dialling key and again dial 99. This proves that dialling is satisfactory over short lines with low insulation.

The bell should not ring. The switch should again drive on to the last contact and give busy conditions.

Momentarily throw the dialling release key to release the connection.

Speed of Dial.—The speed of the dial on the routine tester should be approximately 12–14 impulses per second.

Section 56

VILLAGE EXCHANGE POWER CIRCUIT WITH HAND STARTING AND AUTOMATIC STOPPING

This power circuit (Fig. 118) is suited to the requirements of small telephone equipments with petrol-electric or motor generator charging arranged for hand starting and automatic stopping. A petrol-electric generator is shown in Fig. 119 and a power board in Fig. 120.

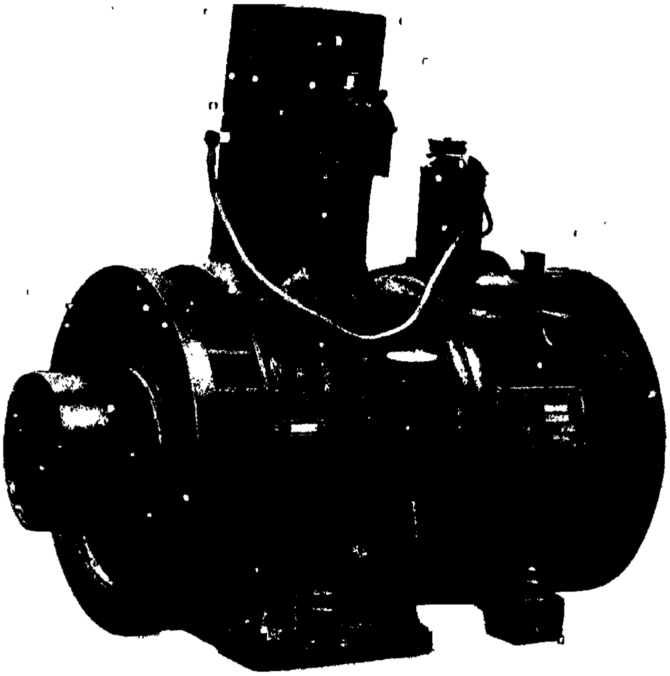


FIG. 119.—VILLAGE AUTOMETER EXCHANGE (SIEMENS). PETROL-ELECTRIC GENERATOR.

Two batteries are provided. The exchange is connected to each battery alternately at each regular visit of the maintenance officer. To charge the idle battery, the petrol-electric set or motor is started by hand before the charge switch is operated.

When the charge put into the battery reaches a certain predetermined amount, a contact on the ampere-hour meter introduces a condition which automatically stops the petrol engine or motor without any alarm being sent out.

During the discharge of a battery the ampere-hour meter in its circuit runs in the reverse direction, and at a predetermined point a contact is closed which has the effect of sending an alarm to the distant manual exchange over a disengaged junction line.

Should the engine or motor fail, or any disconnection take place in the main charging leads after the idle battery has been left on charge, an alarm is sent out to the distant manual exchange and the circuit-breaker is tripped.

Test keys are provided to enable the motor-failure apparatus to be tested when desired.

In the case of a petrol-electric set (Fig. 119), the operation of the motor-failure test key short-circuits the ignition interrupter contact, stops the petrol engine, and introduces the motor-failure condition.

In the case of a motor-generator set, the no-volt coil of the motor starter is disconnected and the motor-failure condition established.

Keys are also provided for connecting the voltmeter to the generator or either of the batteries.

Power Circuit Operation (Fig. 118).

Charging commenced.—It is assumed battery No. 2 has been connected to the exchange and that battery No. 1 is about to be charged. The circuit-breaker is closed, the charging switch being in the off position, and the petrol-electric set, or motor, started up. When the set is running satisfactorily, the charge switch is thrown to charge battery No. 1.

Relay DL (operating through a shunt in the main charging lead) closes contact DL1, which energises relay EA through battery, contact on circuit-breaker, DL1, EA1000, T1, to earth.

Contact EA5 closes, but the circuit-breaker is not tripped, because DL2 is open.

Contact EA2 closes a holding circuit for relay EA independently of DL.

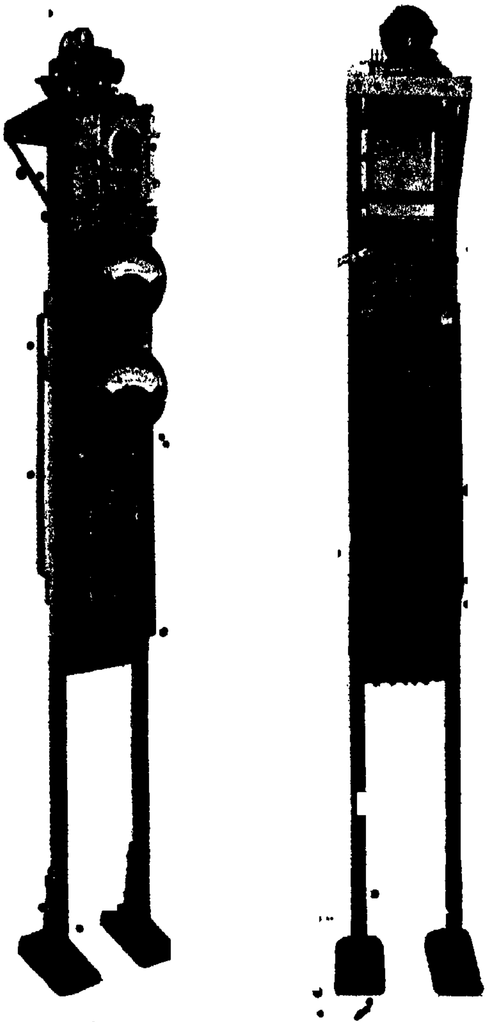


FIG. 120.—POWER-BOARD FOR SYSTEM WITH CLOCK AND VOLTMETER CONTROL (SIEMENS). FRONT AND REAR VIEW

Contact EA1 closes and prepares the alarm circuit, which is not completed, as DL3 is open.

Contact EA4, which is a make-before-break contact, operates, and as DL4 is already up, DL is now made dependent on its own contact DL4. The circuit remains in this condition during charging.

Charging finished.—When the ampere hour meter indicates that the charge required for the battery has been completed, a contact AH1F is closed: this completes the circuit of relay T, which is operated through battery, contact on circuit-breaker, charge switch, AH1F, to earth.

Contact T1 operates, disconnects relay EA, and trips the circuit-breaker.

Contact T2 operates and prevents an alarm being given when DL3 falls back.

When the circuit-breaker is thrown out, relays T and DL are de-energised.

Contact DL3 falls back, but no alarm is given, because relay T is slow-releasing and its contact T2 does not close until contact EA1 is open.

In the case of a petrol-electric charging set, the opening of the circuit-breaker disconnects the primary winding of the ignition coil, thus causing the set to stop. In the case of a motor-generator charging set, the opening of the circuit-breaker disconnects the no-volt release coil on the motor starter, thus causing the starter to return to normal and stop the motor.

All contacts except AH1F are now at normal.

Operation of Alarm Circuits.

Battery Empty Alarm.—Under the assumed conditions, battery No. 2 is discharging to the exchange. When the battery has been discharged to a predetermined value, contact AH2E closes a circuit from battery, AH2E, discharge switch, AR2, SE1000, to earth.

Contact SE1 closes and allows relay SJT to operate when the junction line is free.

When relay SJT operates, contact SJT2 closes a lamp-flashing circuit over the B wire of the junction to the LR relay at the distant manual exchange.

The operator plugs into the incoming jack and operates relay AR through battery, RC, incoming jack springs, A wire of junction, SJT3, AR500, to earth.

Contact AR1 opens the circuit of relay SJT, which opens the lamp-flashing circuit by the release of contact SJT2.

Contact AR2 operates and releases relay SE. Relay AR is now held through its own contact and AH2E, and prevents a lamp-flashing signal being sent out again.

Relay AR is reset by the change-over of the discharge switch.

Charging Failure Alarm.—Should the charge be interrupted, either through failure of the engine or motor, or a disconnection occurring in any part of the charging circuit, relay DL will be released. This release may be effected in either of two ways—(*a*) by the interruption of the current in the main charging lead, or (*b*) by a reversal of current in this lead.

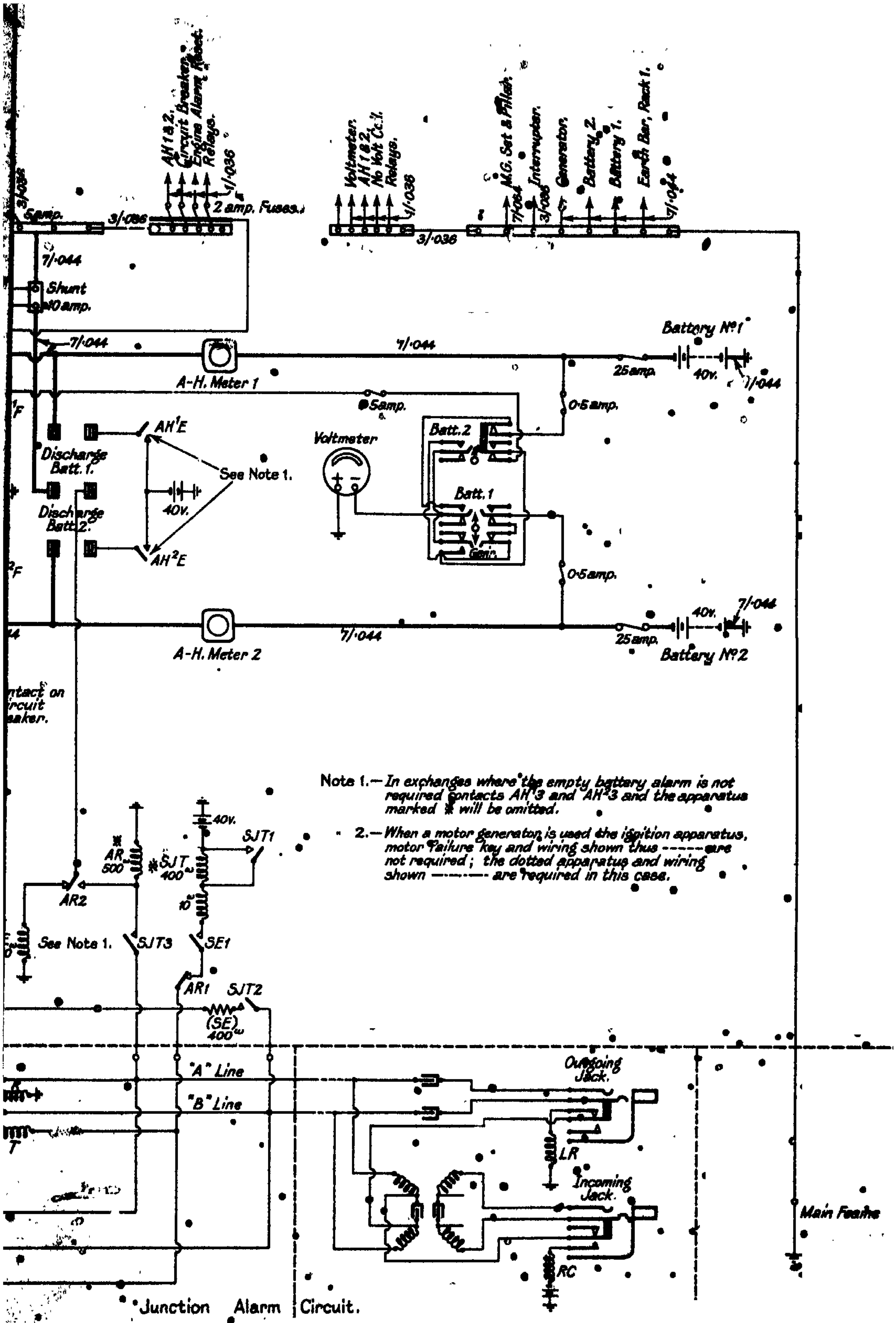
Since DL in its operated condition is dependent on its own contact DL4, it cannot be again operated after once released until relay EA has released its contact EA4.

Failure of the engine or motor through any cause will, of course, result in a reversal of current in the main charging lead.

When relay DL is de-energised, contact DL2 falls back, and the trip coil of the circuit-breaker is operated, from battery or dynamo, trip coil, DL2, EA5, to earth. The circuit-breaker opens, but relay EA is not released, because contact DL1 falls back and provides a holding circuit for relay EA through EA3 and reset key.

The motor-failure alarm lamp lights and the common alarm relay AB is operated through battery, alarm lamp, DL3, T2, EA1, AB500, to earth.

Relay AB connects a flashing equipment to a junction.



Note 1.—In exchanges where the empty battery alarm is not required contacts AH¹3 and AH²3 and the apparatus marked ✱ will be omitted.

2.—When a motor generator is used the ignition apparatus, motor failure key and wiring shown thus ------ are not required; the dotted apparatus and wiring shown —·—·— are required in this case.

("SIEMENS"). POWER CIRCUIT.

Section 57

COMMUNITY EXCHANGES

These are peculiarly American, but may have application in this country for villages, groups of farms, and the like. Mr Arthur Bessy Smith gives an interesting description of these in a paper presented to the American Institute of Electrical Engineers ("Applicability of Automatic Switching to all Classes of Telephone Service," *Transactions*, December 1919), on which the present remarks are partly based.

The community exchange is a small unattended plant for groups of farms, small villages or towns, or suburbs of a town. The installation consists largely of party lines, which may be called by selective or by code ringing. The toll switching and miscellaneous calls, information, etc., are handled from a suitably attended adjacent office.

The equipment is made up of line switches and connectors, with selectors when the capacity demands. The line switch is of the rotary type described on p. 39, Vol. I. Common battery transmission is introduced when possible, but some offices are worked from primary batteries. A weak-current common battery transmitter is mostly used with polarised receivers. The former are necessary because the lines are usually long, and the latter are necessary because they are fitted with a condenser in series to allow of listening-in without interference. A hook-switch latch is fitted to the hook-switch. Normally, with the receiver on the hook, the line is connected to the ringer and its associated condenser. The removal of the receiver, by allowing the receiver hook to rise to its "listening" position (restricted by the receiver-hook latch), disconnects the ringer from the line and connects the receiver in series with the line so as to permit the calling subscriber to listen without interfering. If the line is not in use, the calling subscriber presses a button, thereby releasing the receiver hook, which now operates fully, and connects the transmitter and dial in series with the line. The ringer coils are connected in series with a condenser, so that, when the receiver is on the hook, there cannot be a flow of direct current over the line, but alternating current, which is used for ringing the bells, can pass through the condenser.

The ringing in the best installations is automatic, but some are operated by push-button, drawing current over the line, and sometimes generators are fitted. The line relay is connected from the positive, or earthed, side of the circuit, because, in this position, it has a greater factor of safety than when the relay is double-wound and the two windings connected in series across the loop. Line relays of selectors and connectors are sometimes similarly connected so as to make repeaters unnecessary.

The charging of the battery is preferably by a motor-generator run from the public supply mains. The bus-bars are equipped with a voltage relay which starts the motor-generator when the pressure falls to 46 volts, and stops it when the pressure reaches 52 volts. A self-closing reverse-current circuit-breaker is fitted between the generator and the battery. When the generator voltage is high enough to be safe, the circuit-breaker closes and the charging begins. When the motor has been cut-off by the high voltage the generator voltage dies away until a slight reverse current operates the circuit-breaker and opens the circuit. If no common power is available a gasolene unit is installed. This is started by hand; but is stopped automatically. An ampere-hour meter is in the battery circuit. It runs slowly when starting, but rapidly when discharging. When the necessary ampere-hours have been put into the battery the meter opens the ignition circuit of the engine to stop it. The circuit-breaker disconnects the generator from the battery. During the time of charge the circuit-breaker inserts counter e.m.f. cells in the discharge lead to the power-board. These prevent undue rise of voltage on the bus-bars, which would prematurely stop the charging.

There are signals at the attended office to indicate when a fuse melts, or other fault occurs.

In one case a group of three such installations are located on a line 26½ miles long.

Community exchanges have been fitted in a store, in a bedroom, and may be put in any sort of building centrally located.

TOR OF INDUSTRIES
JUL 1925
ENGAL.

Section 58

COMMUNITY AUTOMATIC EXCHANGES (A. T. M. CO.)

The Strowger Community Automatic Exchange (C.A.X.) System was designed to provide a complete 24-hour-day automatic telephone service to villages and country subscribers at a reasonable cost. Its special features are:—

1. No attendant is required. One inspector can care for a number of C.A.X.'s, making periodic visits to each in turn.

2. The C.A.X. is not dependent on an outside source of electric current. A petrol-engine set supplies the necessary power for charging batteries, etc., if local electric supply is not available.

3. Party-line service, as well as individual-line service, is provided by the C.A.X. Any number of subscribers up to twelve may be put on one pair of wires. Automatic code ringing is employed, so that a calling subscriber has only to dial the number of the particular party desired.

By the use of party lines for country subscribers the cost per telephone for line construction as well as for central equipment is greatly reduced, and the cost of maintenance is correspondingly lessened.

4. Standard automatic telephones and switching apparatus, as used in large exchanges, are employed in the C.A.X., with only such minor modifications as are necessary to adapt them to the particular requirements of the C.A.X. No new or untried mechanisms are used. The C.A.X. has thoroughly demonstrated its efficiency and reliability under actual working conditions, and has given entire satisfaction wherever installed.

General Description of Systems.

The C.A.X. can be applied to four types of systems :—

Fig. 121 *a*. The Isolated C.A.X.
,, 121 *b*. The Tandem C.A.X. System.
,, 121 *c*. The Radial or Satellite C.A.X. System.
,, 121 *d*. The Network C.A.X. System.

(*a*) *The Isolated C.A.X.*

The isolated exchange is relatively rare. It has no connections to or from other exchanges, and therefore the service requirements are of a simple nature.

Fig. 121 *a* illustrates a C.A.X. of this character.

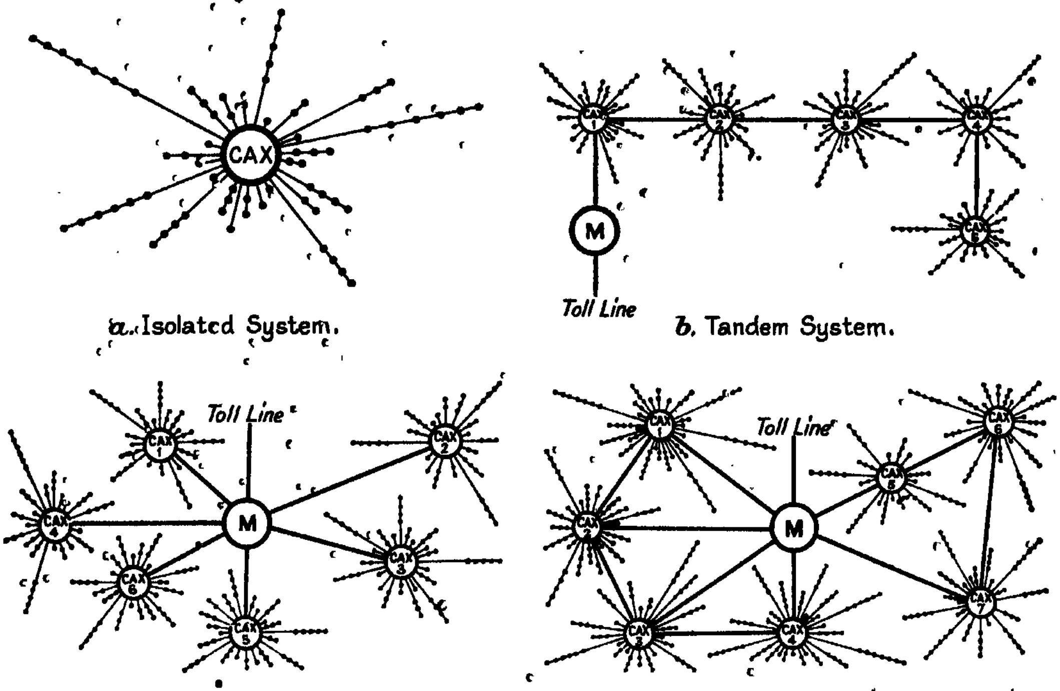
(*b*) *Tandem C.A.X.'s.*

The tandem C.A.X.'s may be connected by means of only one toll line, as shown in Fig. 121 *b*. This toll line not only serves for toll connections between the C.A.X.'s, but also serves as a toll line to distant points.

A C.A.X. can be installed in each town with individual and party lines serving town subscribers, and rural lines serving the country subscribers. All calls within each C.A.X. are made automatically by the calling subscriber. The toll office can be located wherever it will receive the best attention, either at one of the C.A.X.'s or at the distant end "M," which may be either an automatic or manual central exchange. Services such as information, complaint, etc., can be cared for by the distant toll operator or may be handled locally by any suitable person.

Calls from one C.A.X. to another C.A.X. would be handled by the toll operator. The calling subscriber would dial a predetermined number: for instance, "0," and connect to the toll operator; she in turn would dial the called subscriber and would be in a position to supervise the call and record the proper charges.

Referring to Fig. 121 *b*, it is obvious that all the C.A.X.'s illustrated are connector (2-digit) systems, and that the toll operator must employ a selector switch to select a particular C.A.X., and as all C.A.X.'s are connected by means of one line, this line is tapped on to a selector switch at each C.A.X.



a. Isolated System. *b.* Tandem System.

c. Radial System *d.* Network System.

Fig. 121.—Types of Community Automatic Exchange Systems (A. T. M. Co.).

The first level of the selector at C.A.X. No. 1 would be connected, and all other levels left open. At C.A.X. No. 2 the second level would be connected. At No. 3 the third level, and so on.

Should a C.A.X. subscriber in No. 5 desire to call a subscriber in No. 2, he would dial over the loop, and obtain connection with the toll operator. The toll line is at once made busy to all other calls. The toll operator would dial back "simplex" over the toll line. All selector switches, except at No. 5, will step up to the second level (the operator having dialled "2"), which is connected to a connector in C.A.X. No. 2. The remaining digits dialled by the operator operate the connector switch which would connect to the called line.

The handling of traffic is facilitated by having two or more toll lines. One line can be restricted to "through" service and used by the toll operator only, and the other lines can be used both by the C.A.X. subscribers and the toll operator.

(c) *Radial C.A.X.'s.*

The radial, or satellite, system of exchanges consists of a central exchange, either manual or automatic, connected by radial trunks or toll lines to outlying C.A.X.'s. Fig. 121 c represents a typical lay-out in which "M" is the checking centre (controlling exchange) for the group of C.A.X.'s.

Calls from one subscriber to another in the same C.A.X. are completed automatically. If the controlling exchange is manual, a C.A.X. subscriber desiring a connection to a station in another C.A.X. would dial the operator at "M" who would dial and complete the connection to the desired subscriber. Connections between a C.A.X. subscriber and a manual subscriber in "M" are completed by the operator in the usual manner.

Should the central exchange "M" be automatic, and free service be given, any C.A.X. subscriber can dial any other C.A.X. subscriber as well as any main-exchange subscriber. The automatic main-exchange subscriber can also dial any C.A.X. subscriber direct.

If there is a charge for service between the C.A.X.'s and the main exchange or between one C.A.X. and another, the calling subscriber would dial the toll operator at the main exchange, who completes and controls the connection. Separate trunks can be run from the C.A.X. to the central exchange "M," so that combination toll and free service can be given if desired.

(d) *Network of C.A.X.'s.*

Fig. 121 *d* represents a lay-out on the network system of which there are many possible combinations.

This system differs from the radial system shown in Fig. 121 *c* in that there are direct trunks from some C.A.X.'s to other C.A.X.'s. Adjacent C.A.X.'s having direct trunks may be given free service. Calls from a C.A.X. to a central-exchange subscriber may be free or charged for, as desired. This is also true of calls from one C.A.X. (No. 3) to another C.A.X (No. 7) not having direct trunks.

Section 59

C.A.X. CONNECTOR CIRCUIT—MIXED SERVICE WITH AUTOMATIC CODE RINGING (Fig. 122)

This connector has many functions which may be briefly outlined as follows :—

1. Holds the switches nearer the calling line in their operated position.
2. Carries out the vertical and rotary movements of the shaft, under the control of the calling device.
3. Starts a motor when off normal.
4. Has automatic rotary movement on 9th and 0 levels.
5. Cuts off battery feed and condensers on 0 level.
6. Gives a busy signal on 9th and 0 levels when all outgoing trunks are busy.
7. Operates minor switches under the control of the calling device.
8. Selects and rings the proper code call for party lines.
9. Keeps the wipers disconnected during rotation, so as not to interfere with the lines over which they rotate.
10. Tests the called line to find if it is busy. This busy test consists of two parts :—
    - (*a*) A lock to prevent intrusion on a busy line.
    - (*b*) A signal to notify the calling party that the line is busy.
11. Protects the called line from intrusion.
12. Clears the called line of attachments.
13. Rings the called party's bell intermittently.
14. Gives the calling party an audible signal each time the called party's bell rings.
15. Supplies battery current to both parties for conversation.
16. Opens the ringing circuit as soon as the called party answers.
17. Reverses battery to the calling party when the call is answered.
18. Releases itself without interfering with other lines.
19. Releases other switches.
20. Operates an alarm signal if the release circuit remains closed.

The circuits of a community exchange connector (Fig. 122) are numbered in the order of operation as follows :—

Calling Individual Lines.

1. When the calling line is extended to this switch R′(A) energises.
2. Guard relay R2(B) energises.
3. Earth connected to release circuit, to hold other switches.
4. *Vertical impulses.*—Each time R′ de-energises VM4 energises to step the wipers up, R4(C) energises for the duration of the impulses. A ½ M.F. condenser, in series with a 10-ohm resistance to earth, prevents excessive sparking at the impulse springs of R′. A 150-ohm non-inductive resistance, on top of and in parallel with the winding of R4, also helps to prevent excessive sparking at the impulse springs of R′(A). The off-normal springs close on the first vertical step.
5. Earth on the motor start circuit, so as to start the ringing and busy machine. Also closes a part of the release circuit.
6. R8(G) energises. Opens circuit to relay Z(R20). Holds the 125-ohm winding of R9(H) open during impulsing.

After the last impulse of this series R4(C) de-energises.

7. Rotary magnet RM7, of minor switch L, energises and steps the minor switch wipers on to the first contact, thus switching the battery feed from the vertical to the rotary magnet. R6 and RM7 de-energise. A 200-ohm non-inductive resistance on RM7 prevents excessive sparking at the interrupter springs of R6.

8 (partly over circuit 4). *Rotary impulses.*—R′ de-energises for each impulse, and the rotary magnet RM8 steps the wipers round. R4 energises in series with RM8 for the duration of the impulses. The wipers are now on terminals of the called line. The ½ M.F. condenser at R8 prevents excessive sparking at the impulse springs of A. R4 and R6 operate as before described. After the last impulse R4 and R6 de-energise, if the line is free.

9. R9 energises through its 125-ohm winding, in series with the bridge cut-off coil at the called line switch.

10. R9 locking circuit, through its 1300-ohm winding. Impulsing circuit opened to prevent further rotation of the switch. Private bank contact is earthed to make this number busy to other calls. Earth on the private wiper also earths the private normal to the called line-switch and operates the line-switch bridge cut-off relay.

11. Ringing circuit from interrupted generator through 200-ohm winding of R11 (which does not energise).

12 (partly over 11). Automatic ring-back signal to caller.

The back contact of the interrupter relay is connected to earth, and this earth alternates on the line with the ringing current. R11(F) energises when the called receiver is lifted. The copper ring and mass over the core gives it a greater range of adjustment and also reduces the impedance to the ringing current.

13. R11(F) holding circuit, through its 1300-ohm winding.

14. R14(E) energises in the subscriber's loop.

15. Battery reversed to the calling line. Meter or coin collector can be operated. May be used for supervision in connection with toll or trunk boards.

16. Talking circuit through two 2MF condensers. R′ feeds talking battery to the caller and R14 to the called party.

Release.—When the caller replaces the receiver, R′ and then R2 de-energise. Circuit 3 is opened to release other switches.

17. Release magnet *Rel.* 17 energises to free the switch.

18 (partly over 17). *Rel.* 18 returns the minor switch to normal.

19. Circuit to the main release magnet, which remains closed until the wiper returns to normal, to ensure a complete release of the minor switch. When the shaft returns to normal, circuit 17 is opened at the off-normal springs. When minor switch wipers return to normal circuit 19 is opened.

A 500-ohm non-inductive resistance, on top of and in parallel with the release magnet winding, prevents excessive sparking at the off-normal release springs and the bottom wiper of switch L. A 200-ohm non-inductive winding, on the minor switch release magnet, prevents excessive sparking at the main release magnet springs.

Release Signal Relay.—The earth to the release magnet of the minor switch is taken through a slow-acting relay associated with a group of switches, so that, in case the release circuit remains closed, an alarm will be given. This relay is made slow so that the total calls may be registered.

20. If the number called is busy, the private bank contact is earthed at another multiple. R20(Z) energises over wiper P-2.

21. R20 locking circuit. Circuit 9 opened, also circuit 4.

22. Busy tone on positive line to caller.

Busy tone is taken through one of the talking condensers, so that two or more switches calling busy numbers cannot be locked up over the common busy wire. The busy tone is also taken through a condenser common to each unit, so that, in case the busy should become earthed, it will not be out of service in the entire office. R20(Z) is locked to earth at R2(B), instead of at the private wiper, so that it will not restore, and close the circuit to R9, when the called party hangs up his receiver. The caller cannot come in on the called line as R9(H) has not operated.

Ninth Level Calls.—The ninth level is used for groups of trunks on which it is necessary to ring on the trunk selected to operate a ring-down signal. The upper and lower bank contacts of each trunk, except the last one in a group, are strapped together.

In calling a trunk in a group on the ninth level the operation of the vertical and rotary movements of the shaft are as previously described. A pair of springs close as the shaft steps on to the ninth level; and prepare a circuit to R23(J). If the first trunk in the group called is busy, the private bank contact P-2 will be earthed, due to some other switch occupying a multiple of it. Since the upper and lower banks are strapped together on all but the last trunk in the group, both P-1 and P-2 will be earthed. R20 will energise in circuit 20, as previously described.

23. R23(J) energises before R6(G) restores over the rotary interrupter springs.

24. R23 closes a locking circuit to R6 so that R6 cannot de-energise.

25 (partly over 6). Circuit to rotary magnet RM8 which steps the wipers to the next bank contact. R23 de-energises and opens the circuit to the rotary magnet. If this trunk is also in use, earth on P-2 again operates R23, before R6 restores. R23 closes the locking circuit 24 to T6, and rotary magnet, as before. The same cycle of operations will be repeated until an idle contact is found, or the last contact of the group is reached.

If an idle trunk is found, R23(J), R20(Z), and R6(G) restore and close circuit 9 to R9. R9 energising closes the ringing circuit 11, and the connection is completed and released, as previously described.

If all the trunks in a group are busy, the wipers rotate to the last contact in the group. The private bank contacts of this trunk are not strapped together and only P-2 is earthed. R23 and R6 restore, since R-1 is not earthed, but R20 remains operated in circuit 20. When R6 restores it locks R20 in circuit 21, and busy tone is placed on the caller's line as before.

Tenth Level.—The tenth level is used for calling trunks that lead to a repeater or other switch, for which the line circuit must be completed as a clean metallic circuit without attachments.

In calling this O level the ninth level springs close, and another set of springs also close on the O level. The vertical and rotary movements of the shaft, and the automatic selection of trunks, take place as previously described.

26. When an idle trunk is selected and R9 energises, R26 then energises.

27. R26 locking circuit.

28. Wiper P-2 earthed to busy the trunk to other calls. Circuit 20 opened and R20 de-energises. R' and R2 de-energise.

29. The talking circuit is completed without attachments.

Release circuit opened so that the switch cannot release when R′ and R2 de-energise. The switch ahead earths the release trunk 28 before R2 de-energises, so as to prevent this switch from releasing.

Release.—When the caller replaces his receiver the switches ahead release and remove earth from the release trunk. R26 de-energises and closes circuit 17 to the release magnet *Rel.* 17, which releases the switch, as previously described.

If all the trunks in the O level are busy, the busy tone is placed on the calling line in the usual manner.

Party-Line Calls.—When this switch is used to call party lines it operates in conjunction with a special ringing machine.

The vertical and rotary movements of the shaft are as previously described for individual lines. On party lines neither battery nor earth is connected to wiper P–2, but the B.C.O. of the party line is connected to P–1, so that neither R9 nor R20 operate at this time.

After the last rotary impulse R4(C) de-energises and again operates the rotary magnet of minor switch L over circuit 7. The wipers are stepped on to contact 2, which prepares a circuit to the rotary magnet of minor switch N.

30 (partly over 4). As the next series of impulses comes in, R′ de-energises, and the rotary magnet RM30 of the minor switch N operates.

It will be assumed that the third and fourth digits to be dialled are 3 and 4. The three impulses to the rotary magnet of minor switch N step the wipers to the third contact.

31. A circuit is prepared to the rotary magnet of minor switch T, and the bottom wiper of switch N is switched from direct generator to the occupancy tone.

R4 and R6 operate during impulsing and, after the last impulse, R4 de-energises and operates the rotary magnet RM7 of switch L, as previously described. The wipers of switch L are stepped to the third contact, which prepares the circuit to the rotary magnet of minor switch R.

32 (partly over 4). The next series of impulses operates the rotary magnet RM32 of switch R and, since the fourth digit to be dialled is 4, the wipers of switch R are stepped to the fourth bank contact. The bottom wiper of switch R is switched from wiper P–2 to P–1. R4, R6, and the rotary magnet RM7 of switch L again operates and steps the wipers of switch L to the fourth contact, thus preparing the circuit to the rotary magnet of switch T.

33 (partly over 9). R9 operates from battery on P–1 and closes the line circuit as before.

Leads 5, 4, 3, 2, and 1 are earthed in succession, in the order given, with an interval between the earthing of any two leads. Lead 7 is earthed every time either of the above leads is earthed. Lead 6 is earthed by impulses in groups of five, with an interval between each impulse, and a longer interval between each group of five impulses.

34. The rotary magnet RM34 of switch T is operated when lead 3 is earthed by the ringing machine.

35. The rotary magnet RM34 locks itself to lead 7, so as to ensure its complete energisation (7 being earthed at the same time with the same length of impulse that earths leads 1, 2, 3, 4, and 5), and steps the wipers to the first bank contact. The wipers prepare a circuit to their rotary magnet and close the circuit to R36(D).

36. R36 energises.

37. Lead 6 connected to R23(J). Each earth impulse on lead 6 operates R23, which connects direct generator to the line.

38 (partly over 11). *Ringing.*—Ringing current circuit from direct generator to ring the called party's bell, each time R23 energises. After the three impulses have operated R23 the called bell has been rung three times. Lead 5 is earthed during the pause between the groups of impulses on lead 6, circuit 37. As before stated, lead 6 is earthed by impulses coming in groups of five, with a longer pause between groups than between impulses.

39 (partly over 34). Earth on lead 5 operates the rotary magnet RM34 of minor switch T. It locks over lead 7, circuit 35, so as to operate during the entire earth period, and steps the wipers to No. 2 bank contact.

After the pause between the impulses in groups, the next series of five impulses comes in over lead 6. R36(D) remains locked.

37. R23(J) again responds to the impulses and places ringing current on the line circuit 38. After the bells have been rung four times lead 1 is earthed.

40. Rotary magnet RM34 of switch T energises.

41. Occupancy tone is placed on the line during the silent periods, to signal the other parties on the line that a call is being made, in case any of them should lift the receiver to make a call.

The wipers of switch T step to bank contact 3. Circuit 36 is opened and R36 de-energises. Circuit 37 is opened and R23 de-energises, thus opening the ringing circuit 38, because the code ring 34 has been given once.

39. The next impulse on lead 5 operates the rotary magnet RM34 of switch T, and steps the wipers to contact 4.

42. R6(G) energises.

43 (partly over 7). The release magnet *Rel.* 43 of switch T energises, and releases its wipers. R6 is slow and gives time for them to restore completely.

44. The next time lead 3 is earthed, switch T will operate and start the ringing again. The same operation will be repeated and the code ring 34 connected to the line, until the called party answers, or the calling party hangs up his receiver.

If the called party raises his receiver before the code call is completed, the switch will continue to operate and complete the proper call. After R36 de-energises, between code calls, the circuit 11 to the 200-ohm winding of R11 is completed through the called talking loop, and R11 energises. R14 energises and reverses the battery to the caller. The talking circuit is similar to that for individual lines.

If the caller should replace his receiver during the ringing period, R′ de-energises, then R2. R2 prepares the release circuit. The switch cannot release, because the release circuit is held open by R36(D).

45. Circuit to release magnet, through the 300-ohm resistance. *Rel.* 17 does not energise in this circuit, but R4(C) energises and keeps earth from the release circuit, so that R2 de-energises. There will be a short interval in which the release trunk is not earthed, and the switches beyond this can restore.

46. R4 now de-energises and earths the release trunk, so as to make this switch busy while the code call is being completed.

47 (partly over 7). R9 locking circuit, to keep the ringing circuit intact until the code call is completed.

R36 holds circuit 6 open, to prevent R6 from energising and releasing switch T before code call is complete.

48. R36 also holds circuit 48 open to the cut-off relay R26 (on incoming calls only).

After the code call 34 has been completed R36(D) de-energises and closes the release circuit 17, and the switch releases as has been already explained, except that the release magnets of minor switches N (*Rel.* 18′) and R (*Rel.* 49) operate in parallel with the main release magnet, and restore their wipers to normal. Switch T (RM34) is released at the end of the code call.

Incoming Service.—48. For incoming service R26 operates and disconnects the line relay of this switch from the line.

Section 60

POWER PLANT AND AUTOMATIC VOLTAGE REGULATION FOR THE C.A.X.

In the A. E. Co.'s (A. T. M. Co.) community unattended exchanges special attention has been given to the automatic control of the power plant. The following description is taken (by permission) from the A. E. Co.'s journal (*Automatic Telephony*, May 1920, H. E. Clapham).

Current is supplied to the automatic switches from a 25-cell storage battery. The voltage is kept approximately constant by the use of counter E.M.F. cells, one of which is connected in series with the main battery each time the voltage reaches the predetermined limit during the process of charging. Each counter cell develops an E.M.F. of 2·5 volts in a direction opposite to that of the discharge circuit. The plates of the counter cells consist of antimonious lead and contain no active material, and, therefore, the current passing through these cells has only a skin effect, and they are thus prevented from attaining an appreciable capacity.

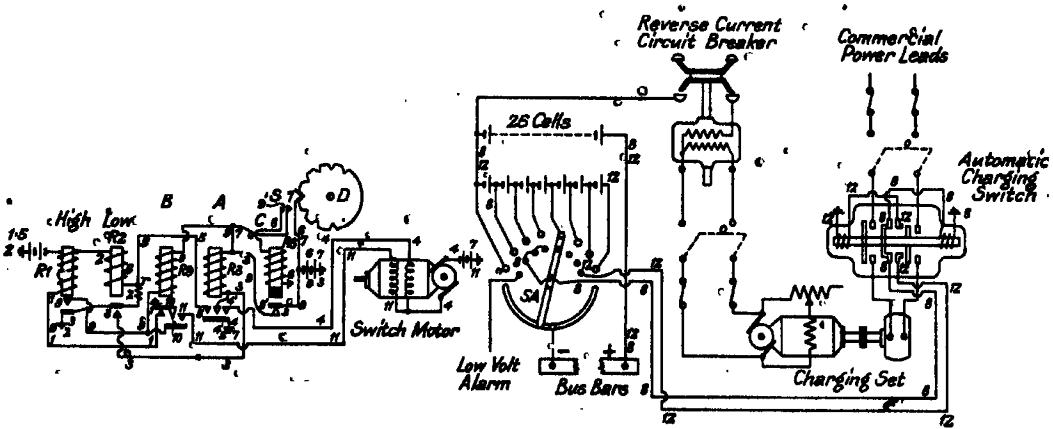


FIG. 123.—AUTOMATIC VOLTAGE REGULATION FOR AN UNATTENDED OFFICE (C.A.X.) A. E. Co. (A. T. M. Co.).

The voltage regulating device is a radial switch having a single heavy copper arm mounted on a shaft. One end of the arm passes over a series of contacts arranged in an arc, each contact connecting with a junction between two counter cells. The switch arm is connected to the negative bus-bar by the opposite end of the arm, which rubs over a continuous arc-shaped contact. Another row of lighter contacts control the circuit to the automatic charging switch. The switch shaft is rotated by a worm-gear driven by a small series motor. The motor has two opposing field windings, one only being energised at a time, so that the switch may be rotated in either direction.

The circuits, shown in Fig. 123, are numbered as follows :—

1. A high-resistance relay R1 is adjusted to energise whenever the bus-bar pressure rises to 52 volts.
2. The low-resistance relay R2 is bridged across the bus-bars in series with a resistance r.

Cutting out Counter Cells.—The diagram shows a period of discharge with four counter cells in the main battery circuit.

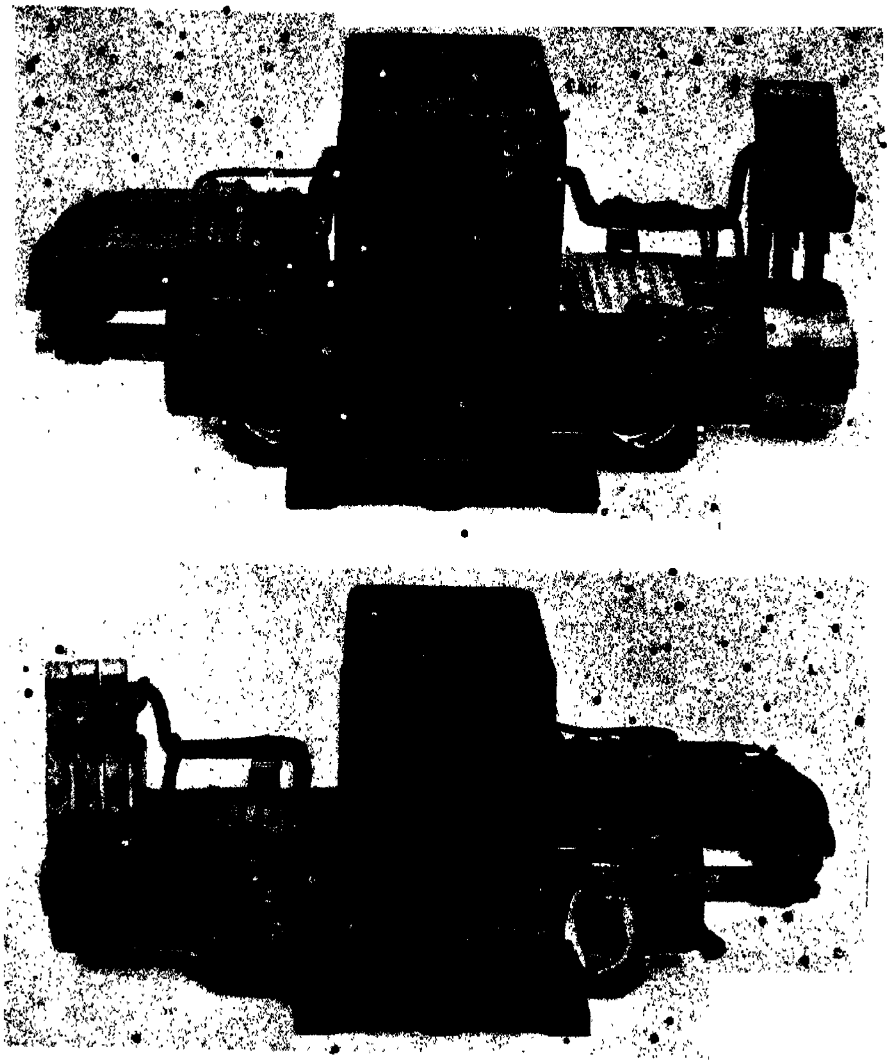


FIG. 123A.—DYNAMOTOR (A. T. M. CO.).

3. If the pressure now drops to 46 volts R2 de-energises, and R3 energises.

4 (4′ locking circuit of R3). Circuit to one winding of the switch motor. The motor now rotates the switch arm SA counter-clockwise, so as to cut out a counter cell, thus increasing the pressure by about 2·5 volts.

5. Resistance *r* shunted. The increased pressure causes R2 to re-energise.

Rigidly fixed to the rear end of the switch shaft and rotating with it is a cam, D.

6. When D rotates the springs S are closed and R6 energises.

7. R3 is maintained energised.

When the switch has rotated to the next counter-cell terminal the contacts S are opened. R3 de-energises before R6 (slow). The cam is so designed that the switch brush and the counter-cell contacts are correctly aligned before the motor stops.

When the potential again falls to 46 volts, this action is repeated.

One counter cell is maintained in series as a reserve.

Automatic charging.—The automatic charging switch consists of a pair of rugged knife blades carried on a rod between two solenoids. One pulls the switch open and the other closes it. When the switch is closed an auxiliary knife blade on the rod opens the circuit of the closing solenoid and prepares the circuit to the other.

8. When the counter-cell switch has been rotated to the point where there is but one counter cell in the main battery circuit, the automatic charging switch closes the current power leads to the motor of the charging switch. When the motor generator starts the generator voltage rises until it is able to operate a self-closing reverse current circuit breaker, which connects the generator to battery. This circuit breaker is of the ironclad solenoid relay type and has two windings. The series winding is in the negative charging lead, and the shunt winding is directly across the generator leads. When the pressure of the generator rises to a point safely above that of the battery, the shunt winding pulls down the plunger, against the action of a spring, and closes the charging circuit. The current now flowing through the series winding assists in holding the plunger down firmly.

When the pressure across the bus-bars reaches 52 volts, the high-resistance relay R′ energises in circuit 1.

9. R9 energises.

10. Locking circuit of R9. Circuit 1 opened and R′ de-energises.

11. Circuit through armature and the other field winding of the switch motor. The switch arm SA now rotates in a clockwise direction so as to place one or more cells in the battery circuit. At that time circuit 2 is opened at 9′ by cam D opening contacts S as before.

Each time the voltage reaches 52 the counter switch is thus operated, to place one or more cells in series with the main battery.

12. When all counter cells are switched in, and fully charged, the counter switch will cause the right-hand solenoid winding of the charging switch to energise and open the circuit of the motor charging set. When the motor is cut off the line the set falls in speed to zero. As soon as the generator falls to a value slightly below the battery the current will reverse its direction, flowing from the battery into the generator. This causes the series winding of the circuit breaker to oppose the shunt winding, so that the plunger is released and the charging circuit opened, before the reverse current reaches an unsafe value.

When commercial power is not available for the twenty-four hours the counter cells close the charging switch when there are still two or three cells in the battery circuit (by strapping together two or more contacts as shown). The power circuit is then closed to the generator before the battery is fully discharged. When all the counter cells are cut off an alarm is given at the main office.

Charging Machine.—As above stated, the charging equipment usually comprises a motor-generator set consisting of a motor arranged for automatic starting direct connected to a generator of sufficient size and of proper design for use in connection with the particular telephone battery with which it is associated. When a gasoline engine driven generating set is used, it must be used with a generator that does not cause inductive disturbances on the telephone circuits. Therefore, it is not feasible to use generating sets as are supplied for "farm lighting" outfits, as practically all of these sets have the ignition circuit for the engine taken from the dynamo direct. This causes disturbances that cannot be readily eliminated or smoothed out by means of impedance (choke) coils.

The generator voltage, and at the same time the current output, is controlled by means of a field regulator, which is an adjustable resistance connected in the field-coil circuit of the generator.

Ringing Machine.—The ringing apparatus, which is mounted on the power board, consists of a rotary converter, the motor circuit of which is operated from the exchange storage battery. This converter generates an alternating current at about 75 volts, said current being carried through a pair of interrupter contact springs mounted on the machine. These springs are periodically closed by a rotor cam and, when in the closed position, interrupted ringing current is delivered to the connector switches for ringing on individual lines or on trunk lines to a distant exchange which require that the signal be "rung down." In addition, the machine is arranged with a distributor which furnishes interrupted earth to the "mixed" service connectors. These interrupted earths cause certain relays in the connector to impulse, said relays, under control of the distributor, project ringing current of the proper ringing code out on the party line. The ringing machine is shown in Fig. 123A.

The ringing machine is so arranged that it will run only when there is a call in progress. During periods when there is no calling, or when the switches are in talking position, this machine is idle, but it starts again as soon as another call is originated.

This machine also furnishes the busy tone, said tone being produced by a commutator type high-frequency interrupter. Through two brushes, making contact with this commutator, is produced the high-frequency tone, and this tone is in turn carried through interrupter springs, on the cam wheel end of the machine, which break this tone up into the familiar interrupted busy tone. The intensity of the busy tone is stepped down by means of an induction coil mounted on the rear of the power board, and from that point the busy tone lead is carried to the connectors through a condenser mounted on the line switchboard.

The ringing machine is mounted on the power board panel. It is arranged so as to be readily removable in case of necessity. It is recommended that a spare ringing machine for one or more C.A.X.'s be provided to be used in case of an emergency.

Storage Battery.—The storage battery consists, usually, of 25 regular cells and 7 C.E.M.F. cells. The counter cells (sometimes referred to as "counter voltage cells" or "counter electro-motive force cells") consist of grid assemblies only, which cannot store up a charge, and consequently have no storage capacity. However, when current is forced through them they exert a back pressure against the current flow which varies according to the load.

These cells are used for the purpose of keeping the battery voltage on the switchboard below the maximum permissible limit when the battery is being charged, and up to the time when the charge is completed. The positive side of the battery is usually connected to earth, this being done merely as an extra precaution to guard against damage to the switchboard, in case a telephone line should become crossed with some foreign source of high voltage current.

The storage battery is usually mounted on a rack in a room separate from the automatic switchboard. It is required that the room in which the storage battery is installed be well ventilated. A lead-lined vent to the outside air is recommended.

In some cases, when space does not permit otherwise, it may be necessary to locate the storage battery in the same room as the automatic equipment. In cases of this kind, a fume-type battery cabinet is supplied. A lead-lined vent should be provided from this battery cabinet to the outside air to permit the acid fumes to escape.

Supervisory Signals.—To give prompt indication of conditions which might result in interference to the service, or damage to the apparatus, there is provided a system of alarm signals for the C.A.X. equipment. The control apparatus for these supervisory signals is mounted on the rear of the power board. If the C.A.X. is left unattended, these signals can be extended to the nearest exchange that is attended, and the C.A.X. can be supervised from that point.

Section 61

VARIOUS SERVICES ON AN AUTOMATIC SYSTEM, AS IN A COMMUNITY EXCHANGE.

Fig. 124 is an interesting Strowger circuit illustrating various services in an automatic system. Whilst these are shown combined in a particular way, they may be applied in other ways to meet other requirements.

The arrangements show :—

Reversal of current for metering, signalling, and the like.

Working four stations on a party line, with harmonic ringing.

Eight stations on a party line, with harmonic ringing, and one and two bell calling to reduce number of codes.

Working local subscribers on eight levels on a connector, trunks to other manual exchanges on the ninth level, and trunks to automatic distant exchanges on the tenth level.

In the latter case the local feeding bridges are cut out of circuit and a clean metallic circuit connected through at the connector.

Repeater working on bothway trunks is shown beyond the connector.

In party-line working the circuit shows how revertive calls are dealt with.

In working to manual exchanges discriminating means are shown by which an operator knows what lines are to have free connections and which are to be registered for charging.

The circuits are numbered and are as follows :—

Party-line Working.—When a subscriber lifts the receiver to call, a locking lever prevents the switchhook from rising beyond an intermediate position, so that he can listen to ascertain if the line is idle.

1. Receiver is connected to line through a condenser.

2. If line is idle the locking switch is moved by hand when the loop circuit is completed in the usual way. The line relay energises.

3. The receiver circuit.

4. The line switch energises to pull down both armatures. Line relay de-energises. Plunger enters bank contacts.

5. Calling line is extended to impulse relay IR of selector ; IR energises.

6. Guarding or holding relay energises.

7. Holding circuit. For lines to be metered this is connected directly to battery.

7'. For lines having free service the holding circuit is connected through tone test winding TT to battery.

Subscriber dials first digit.

8. Relay PMR and vertical magnet VM energise to lift wipers to desired level.

9. Circuit with non-inductive winding of impedance coil IC in parallel with circuit 5, to reduce impedance and resistance of line circuit.

10. Stepping relay SR energised ; shaft having been raised the normal contacts SC are closed.

11. Locking circuit of SR.

12. When impulses cease, PMR de-energises and rotary magnet circuit is completed. SR and RM interrupt the circuit of each other until an idle trunk is found.

13. Circuit of idle line. Switching relay SwR energises, IR and G de-energise
14. Holding circuit of SwR. SR does not energise in series with SwR.
15. Loop 2 and 5 extended to relay IR and impedance coil IC of connector.
16. Guarding relay G energised.
17. Holding circuit 7 and 14 extended through transformer T to connector.

Calling a Local Subscriber.—The talking and test circuits of the four top levels are shown, the test terminals above wipers *a* and *b*, the line terminals above wipers *f* and *g*. Wiper *a* is not in use for a local call. The tenth level is for trunks to automatic exchanges.

The ninth level for trunks to manual exchanges.

The other eight levels are for local connections.

Second digit impulses.

18. Impulse circuit to energise vertical magnet VM. Relay PMR energised for duration of impulses.

19. PMR connects low winding of IC in parallel with high (as circuit 9).

20. Private magnet PM energises. When it de-energises after impulses, the side switches are moved to the second position.

Third digit impulses.

21. Rotary magnet RM steps wipers round to line called. PMR and PM energised. On de-energising the side switches are moved to the third position.

If the line called tests busy—say, with test terminal *c* earthed and side switches in second position.

22. Test circuit in which test relay TR and PM energise and the latter prevents the side switches moving to the third position.

23. Holding circuit of TR.

24. Busy tone signal to calling line.

25. Receiver replaced. IR and G de-energised. Release magnet *Rel.* energised. Shaft falls and breaks normal contacts.

Selective Ringing on a Four-Party Line.—If the line is idle, the side switches are in the third position.

Fourth digit impulses.

26. Relay IR de-energises intermittently. PMR energises in series with stepping magnet SM of ringing switch RgS, the arm *e* of which selects one of four ringing generators.

27. The interrupter *int* intermittently completes circuit by energising relay R27.

28. Ringing circuit over called line by wipers *f* and *g*. Relay RCO energises to cut off ringing when called subscriber answers.

29. Locking circuit of RCO.

30. Circuit to wiper *a* complete through R30, but no circuit beyond wiper, R30 therefore does not energise.

31. Loop 2, 5, 15 extended to connector wipers *f* and *g* and called line.

32. Battery-feeding circuit to called line.

32′. Short-circuiting line to transformer T, which has no function in a local call.

33. Back-bridge relay BBR energising reverses current to calling line. May be used for metering or signalling. The line between the two stations is divided by the condensers. The release of the circuit is brought about in the usual way when the receiver is replaced.

Ringing a Station on an Eight-Party Line.—The stations are divided into two groups of four, each having four frequencies. The groups are selected by code ringing, one group having single strokes and the other by double strokes on the bells. In one case, the interrupter has two conducting segments to pass two short rings, then a longer silence for each revolution; in the other, there is only one segment passing ringing current per revolution. The eight stations may be numbered—1841, 2, 3, 4; 2841, 2, 3, 4, the last digit of each number in each case operating the ringing switch RgS to select the required frequency, whilst the first digit determines the group of connectors to be used, and, therefore, whether one or two segments shall be associated with the selected generator for code ringing.

Reverting Calls, to stations on same party line.

The caller dials the wanted number, and a particular digit extends the line to a reverting switch. The following digit impulses raise the wiper to the ring-back level, and the wipers are rotated to the required contacts by the final digit. The caller then replaces the receiver, and the correct ringing current is sent to the called party. The caller's bell is also rung, so that when it ceases he may know that the connection is through and again remove his receiver.

The wipers *h* and *j* engage with the fixed terminals shown above the wipers.

Common to all the ring-back switches is a rotary ringing switch RRS. SM is its stepping magnet, *int* interrupter relay, *k*, *m*, *o* wipers, and 25 sets of fixed terminals. The numbers allocated to party-line subscribers determine the connections between terminals in the switch banks and the top terminals of switch RRS.

34. When the loop 2, 5, 15 is extended to the ring-back switch, RBS and IR energise.

35. Guarding relay G energises.

Third digit impulses.

36. Impulses cause IR to de-energise. PMR and VM energise. The shaft is lifted to the corresponding level. PMR de-energises after impulses and moves the side switches to the second position.

Fourth digit impulses.

37. PMR and rotary magnet RM energise to step wipers round; PMR de-energising moves side switches to third position.

Suppose wipers on terminals *p*, *q*.

The caller replaces the receiver and IR de-energises.

38. Relay R38 energises, also PMR.

39. Starting circuit for rotary switch RRS.

40. Circuit for interrupter relay. After the first step wiper *m* is earthed by all the lower terminals and the switch RRS makes a complete revolution, and continues to rotate so long as R38 is energised.

41. When the wipers *k*, *m*, *o* reach terminals *r*, *s*, *t*, ringing relay Rg is energised.

42. Generator AC2 is connected to called-party station. RCO does not energise.

When the wipers *k*, *m*, *o* reach terminals *u*, *v*, *w*, ringing is re-applied: two short rings thus being sent from AC2 generator.

This code ring is repeated for every rotation of the switch RRS.

When the called party answers, RCO energises in circuit 42.

43. Holding circuit of relay RCO.

46. Relay RCO opens holding circuit 17, so that IR and C de-energise to release this switch. The group selector and line switch also de-energise. As the loop is completed on the party line, the line switch re-energises and extends the line again to a selector from which microphone battery is supplied.

Connections to Distant Automatic Exchange.—Dialling as before lifts the wipers to the tenth level.

As indicated by *r*1, *r*2, *r*3, there are three groups of trunks to different exchanges. Wiper *a* makes contact with these upper test terminals. To call a line in the *r*3 group the wipers are rotated to the seventh terminal.

If the called line is engaged—

47. The side switches are locked in the second position by PM. Test relay TR energises over wiper *b*.

48. The rotary magnet energises over wiper *a*. RM moves wipers round to next line and at the end of the stroke—

49. Earths PM and opens circuit 47, so that TR de-energises. TR opens circuit 48 to de-energise RM. Side switches move to third position.

If all the trunks of a group are busy, RM cannot energise in series with resistance *r*3.

50. Relay R30 energises over wiper *a* and shaft contact SC, the latter is only closed when the tenth level is used. Relay BBR de-energises.

51. Relay RCO energises.

52. A clean metallic circuit is extended by wipers *f* and *g* to IR of repeating circuit.

This trunk is arranged for bothway working, the lines *aa* connecting with line switches for incoming calls.

53. Guarding relay G energises.

54. Second slow release relay R54 energises. R54 opens bridge across test leads 50, 50′. Circuit 50 is extended to keep R30 energised.

55. Impulse repeater circuit. R55 energised.

56. Slow release relay R56 energised.

57. Repeater condenser short-circuited.

58. Circuit to line switch, which is energised to find an idle selector to further extend the line as required. Further digit impulses are repeated to selector by relays IR and R15.

When the caller replaces the receiver, IR, R15, and R56 de-energise and release the connection.

When calls are made in the reverse direction, relay IR′, G′, R55′, and R56′ operate in the same way as IR, G, R55, R56.

Connections to Distant Manual Exchange.—The first selector lifts the wipers of the connector to the ninth level, which may contain two groups of trunks to different manual exchanges. The extent of each group is indicated by the absence of connection to upper test terminal.

To call the second group, the wipers are moved to the fourth set on the ninth level. If the first trunk is engaged, the side switches are locked in the second position, and the wipers further rotate to find an idle trunk in the manner described for calling an automatic trunk. The upper and lower contacts are connected as shown, except the last. R30 is not energised, as the shaft contact SC is not closed for the ninth level.

The caller sends additional impulses to cause ringing current to operate the indicator. The call is then extended manually in the usual way.

Subscribers who are entitled to free calls have their line switches connected through a tone test winding, as previously described (circuit 7′). When answering such a call the operator's set is first bridged across the line with a condenser in circuit to get the signal, the condenser then being cut out so that the relay BB of the connector is energised to cut out the signal.

SUPPLEMENT TO VOLUME I

POST OFFICE STANDARD DIAL, No. 8
NEW PATTERN WALL AND TABLE INSTRUMENT. A. T. M. CO., A. E. CO.
CONVERTIBLE WALL AND TABLE INSTRUMENT, WITH
H.M.T. SIEMENS
AN IMPULSE EQUALISING DEVICE. A. T. M. CO.
CONDENSER DEVICE TO REPEAT SENDER IMPULSES. LAIDLAW
AN IMPULSE CONVERTER. R. A. T. CO.

DIRECTOR OF INDUSTRIES
LIBRARY.
13 JUL 1925
BENGAL.

Section 62

BRITISH POST OFFICE STANDARD DIAL, NO. 8

In connection with this device the Department has made a very important departure from the usual practice and, from their point of view, a very desirable result is obtained. Hitherto it has been the practice to accept dials of different designs from various manufacturers, but in an endeavour to obtain uniformity of practice, simplification of stocks and maintenance, one design has been adopted as a standard, which is known as "Dial Automatic No. 8."

The dial is illustrated in Figs. 125–130.

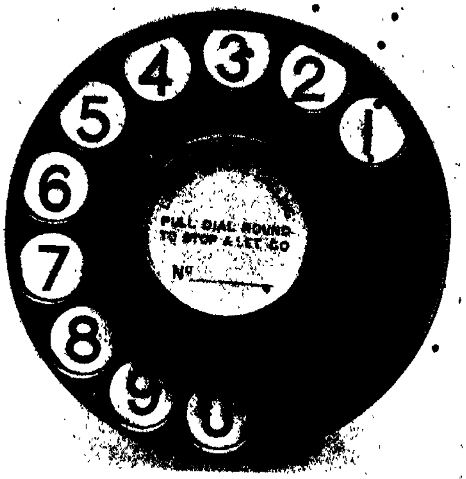


FIG. 125.—P.O. STANDARD DIAL, NO. 8. FRONT.

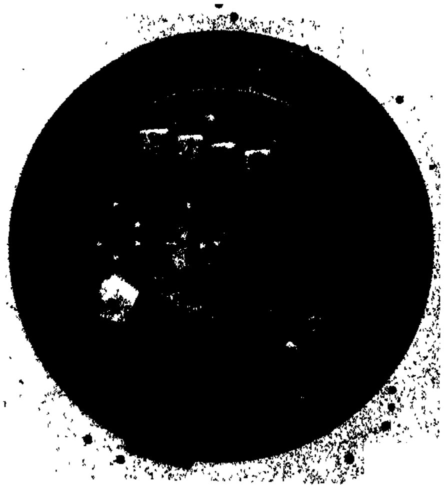


FIG. 126.—P.O. STANDARD DIAL, NO. 8. INTERIOR.

The present standard 3-point fixing has been retained. As will be seen from Fig. 125, there is a considerable gap between the finger hole 1 and the stop, to allow of an interval of time between the completion of the pull to the stop and the sending of the first impulse.

A rotating impulse cam, with teeth controlling the impulse springs, is used, instead of a geared rotating fibre segment opening the impulse springs. The impulse cam is readily removable, so that another cam with differently spaced teeth, to suit a particular system, can be inserted.

From the illustration of the rear, Fig. 127, it will be seen that the springs are assembled as a unit, so that they can be removed without the adjustments being disturbed. The clock-like driving spring is housed in a spring box situated underneath the impulse cam.

Impulsing.—The impulses are produced by the impulse cam which, operating in conjunction with the impulse lever, causes the impulse springs to open and close. These impulses are positive and clean, and of uniform duration. In other dials the impulses are produced by the contact springs being forced apart for the break, and then allowed to fall together for the make. The latter operation results in vibration, the main break being followed by a series of minute breaks, as shown on an oscillogram, Fig. 130A. In a circuit in which there is considerable inductance, the vibration tends to shorten the period of make, but where there is considerable capacity, such as that due to a telephone condenser, the make period is not shortened. In the new dial the contact springs are normally held together, and permitted to fall apart for the break period. In this way vibration is eliminated, as shown in Fig. 130B. The lengths of the periods of make and break depend upon the width of the teeth of the cam. No ratchet and ratchet wheel are now necessary.

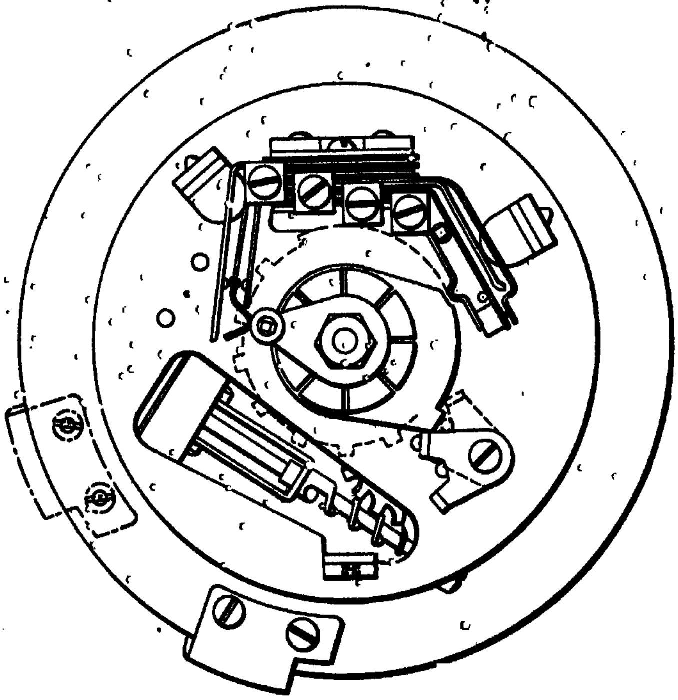


FIG. 127.—P.O. DIAL, AUTOMATIC, NO. 8. INTERIOR. HORIZONTAL SECTION.

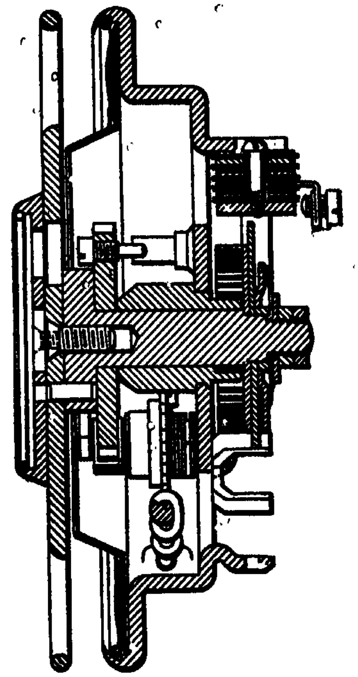


FIG. 128.—P.O. DIAL, AUTOMATIC, NO. 8. TRANSVERSE SECTION.

A dial fitted with a standard cam sends ten impulses per second, the length of each break being 63 milliseconds (·063 second), and of each make 37 milliseconds (·037 second). Cams to give other ratios of break to make can be fitted.

Minimum Pause.—This is an arrangement by which a certain minimum time (about 300 milliseconds) must elapse after the release of the dial plate and the sending of the first impulse, to ensure that selectors have time to perform their hunting operation. Without this facility it is possible when dialling numbers, such as 1-1-1, for the impulses to arrive before a free selecting switch has been found.

This minimum pause is provided for by the slipping cam fitted above the impulse cam, as shown in Fig. 127.

The function of the slipping cam is to screen two of the gaps in the impulse cam, so that when the dial is actuated and released, a pause, equivalent to two complete impulses, is made before an impulse is sent, thus definitely providing the time required by the exchange apparatus to find an idle line in all circumstances.

The action of the slipping cam is dependent upon the phosphor-bronze spring washer, which provides sufficient friction to ensure satisfactory action without causing the cam to wear.

Provision is made for the retention or elimination of this feature as required. Such

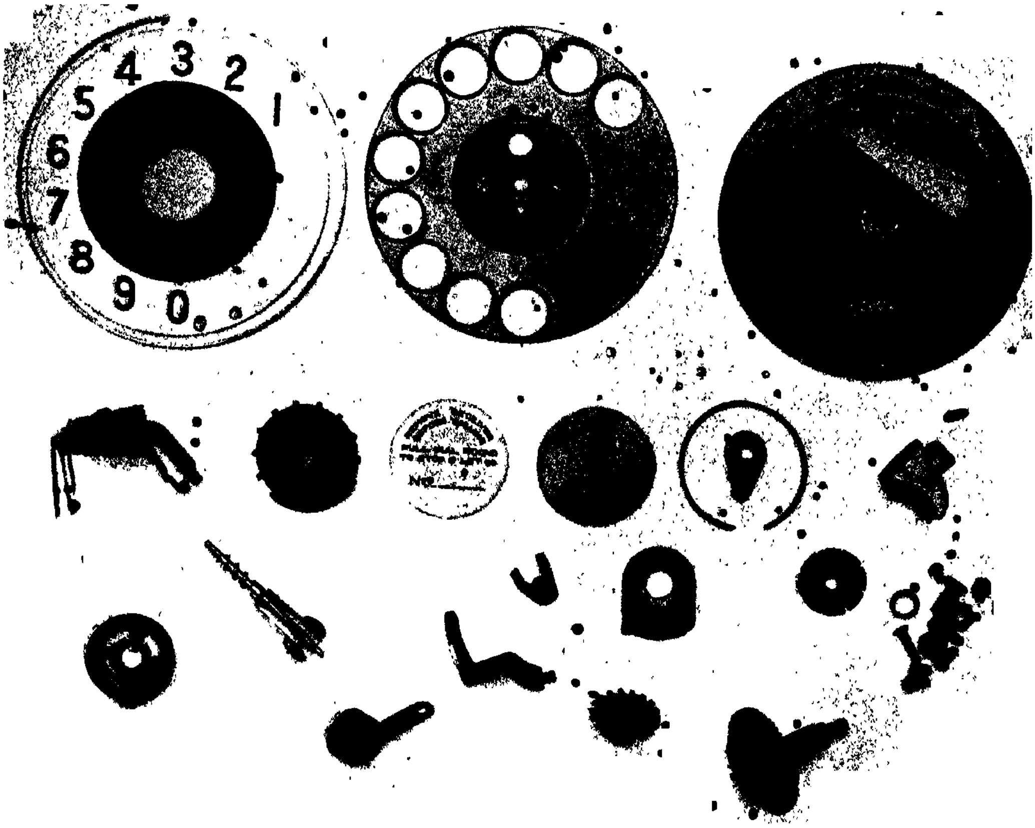


Fig. 129.—P.O. Standard Dial, No. 8. Parts.

changes are easily effected by altering the position of the finger-stop and the stop for the slipping cam. No additional parts are required, and extra holes are provided for the purpose of making the change.

Speed Control.—The governor is of the worm and worm-wheel type, so proportioned as to give uniform control over a considerable range of speeds—from 7 to 14 impulses per second. It is difficult to accelerate or retard the dial seriously.

Accessibility.—Certain replacements and adjustments can be made without removing he dial from the telephone, or interfering with the running and adjustments.

Upon removal of the wire ring and instruction label, two screw-heads are exposed. The centre screw secures the finger-plate, the other is the spring tension and stop screw. To allow the dial to run down, or to alter the spring tension, the stop screw is slightly withdrawn out of engagement with the fixed stop (the screw may be moved back only a few turns), when any required alterations may be made.

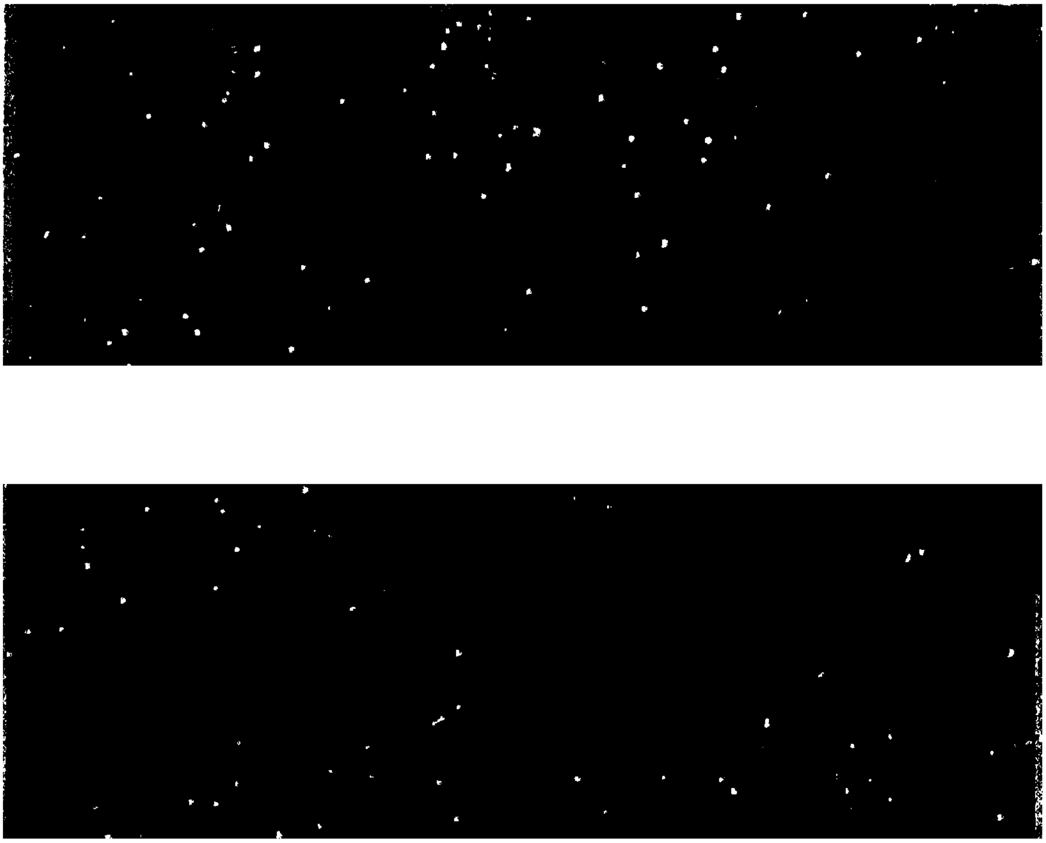


Fig. 130.—Impulse Oscillograms.

To change the enamelled number ring, the centre screw is taken out and the finger-plate lifted off. The number ring is held in position by a circular spring wire, on removal of which the former can be lifted out.

To change the impulse cam, main spring, or spring unit, or to make governor adjustments, the dial must be removed from the telephone. After the removal of the finger-plate and number ring, the whole of the interior is open for inspection, including the gearing, which consists simply of a wheel and pinion, and the governor.

The adjustment of the contact springs is as follows :—

Contact pressure at normal	20 to 30 grams.
Tension to lift lower impulse spring only from ebonite pip on lever	5 to 10 grams.
Contact opening	14 mils.
Follow of upper impulse spring when contacts close, *i.e.* the distance between the end of the buffer and the impulse spring	6 mils.

Section 63

A NEW DESIGN OF WALL AND TABLE INSTRUMENTS (A. E. CO., A. T. M. CO.)

These are shown in Figs. 131 to 134. The transmitter and cup assemblies of the two instruments are interchangeable. The mounting neck is of solid aluminium bronze, finished in black enamel. The hinge, permitting of vertical movement only, is concealed in the transmitter cup.

The pillar of the table set is now placed out of centre to give greater stability, and protection to the dial.

The receiver hook and spring assembly are also interchangeable on both types of instruments, and in the table set may be lifted 4 inches clear, as shown in Fig. 134, to allow of examination. In the wall instrument and bell-box for the desk set the bell gongs are placed in a lower chamber slotted to the outside, as shown in Fig. 132. All parts are readily detachable for examination and replacement.

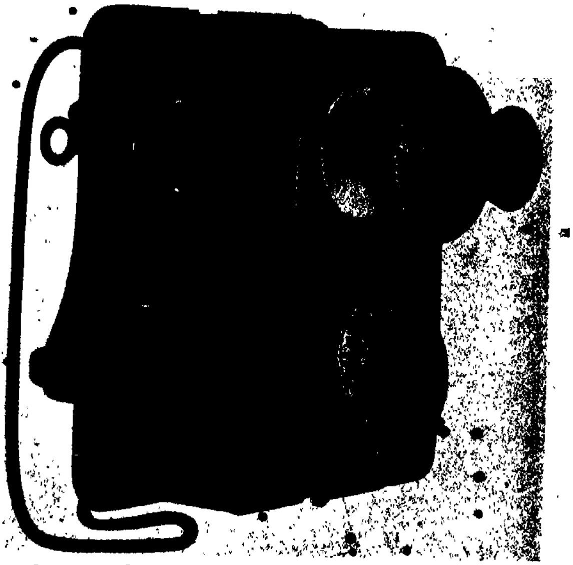


FIG. 131.—WALL TELEPHONE (A. T. M. CO.). LATEST DESIGN.

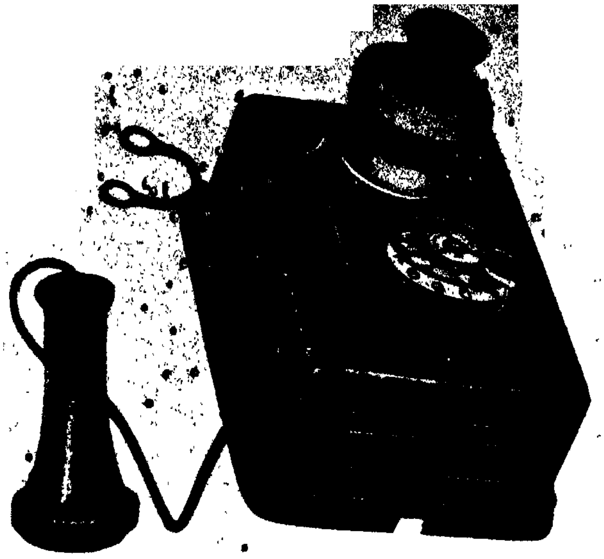


Fig. 132.—Wall Telephone (A. T. M. Co.) showing Slotted Chamber for Concealed Bell.

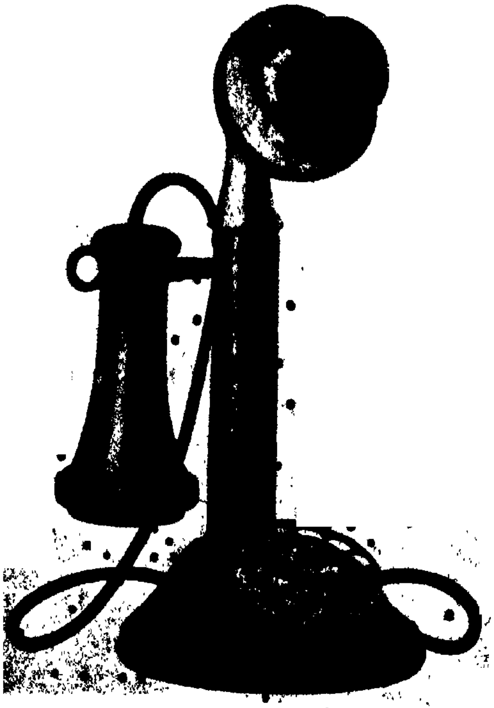


Fig. 133.—Table Telephone (A. T. M. Co.). Pillar out of Center.

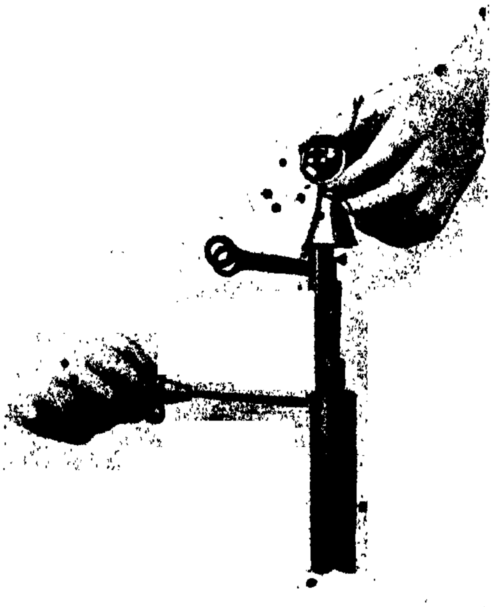


Fig. 134.—Table Telephone (A. T. M. Co.), Switch Exposed.

Section 64

COMMON BATTERY WALL AND TABLE TELEPHONE—METAL CASE, HAND MICROTELEPHONE PATTERN, AUTOMATIC TYPE (SIEMENS)

The common battery metal case wall or table telephone is fitted with hand microtelephone, and is suitable for either manual or automatic systems (Figs. 135 to 137).

When used as a table telephone, it is provided with a terminal block on which the office wire is terminated, and with a cord between the terminal block and the instrument.

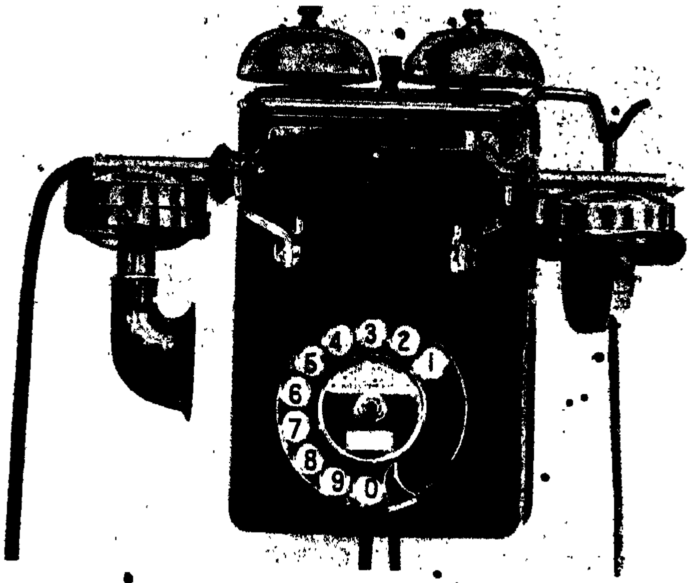


Fig. 135.—Automatic Wall Instrument (Siemens).

When used on automatic systems, it is equipped with a dial holder and a dial switch.

When used on manual systems, a cover plate is fitted in the position occupied by the dial mounting.

To convert it from wall pattern to a table pattern, the nuts of the switch cradle are loosened and the cradle rotated through 90°. In the case of an automatic instrument the clamping screw of the dial holder is slackened and the holder rotated, so that the dial presents a suitable slope.

Construction.—The case is of pressed steel, finished black, and is hinged to a steel base. This in turn is fixed to a steel back plate.

The back plate referred to above fits into the back of the base to which it is secured by a single screw. This provision is made so as to permit the back plate to be secured to the wall independently of the instrument (when fitted as a wall set). The back plate is secured to the wall by two screws, which pass through two holes in convenient positions in the back plate. These two holes are arranged at the same level in order that there may be no difficulty in finding suitable positions for the wall plugs in brickwork. Both plugs may be placed in one horizontal joint.

The back plate is fitted with four feet. These feet are of soft rubber, a necessity when the instrument is used as a table telephone. In fitting the instrument the line wires are first brought up and clamped to the base plate, and then connected to the terminals of the instrument when the latter is fixed.

When arranged for automatic working, the complete telephone contains: magneto bell (1000 ohms), induction coil wound with two windings of silk-covered wire to 1400 and 1700 turns (approximate resistances of 17 ohms and 26 ohms respectively), condenser (2 microfarad), hand microtelephone of the interchangeable capsule type, hand microtelephone cradle and switch, dial switch, dial switchholder and the necessary terminals and cords.

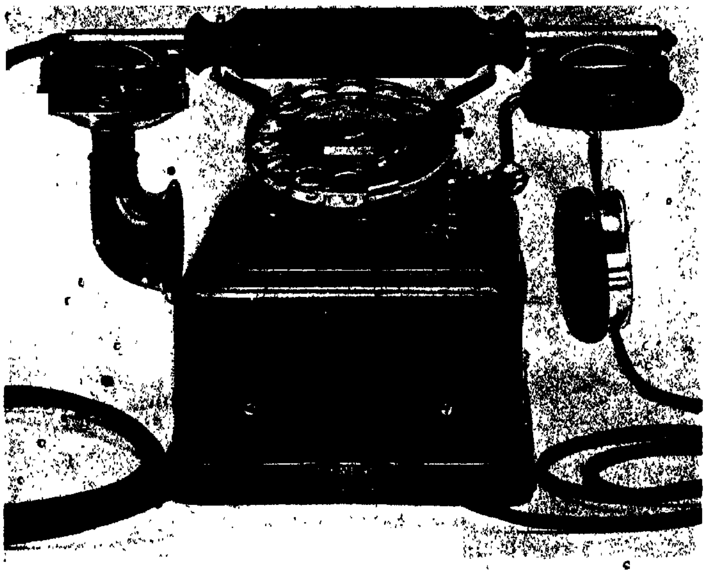


FIG. 136.—AUTOMATIC TABLE INSTRUMENT (SIEMENS).

Hand Microtelephone.—This has the capsule insulated from the frame. The connections of the flexible four-conductor cord are all located in the transmitter case. This greatly facilitates the changing of cords—generally a troublesome matter on hand microtelephones—reducing the cost of maintenance due to faulty cords and cord replacements.

The transmitter is of the interchangeable granular type insulated from the frame. The transmitter mouthpiece is of ebonite, British Post Office pattern, and is fitted to a transmitter front which is secured in turn to the case by means of a bayonet joint. This construction has been found very durable.

Cradle Switch.—The switch is self-contained and easily adjusted. All springs are of nickel silver fitted with gold-silver contacts.

Difficulty has been experienced with telephones used on automatic systems through impulses being sent unintentionally, due to the accidental movement or jerking of the cradle when removing the hand-microtelephone. This causes an additional impulse to be sent to the exchange switches, resulting ultimately in a wrong connection.

In order to overcome this difficulty, which is particularly noticeable on systems using hand-microtelephones, the cradle switch and cradle are constructed in such a manner that the action of the contact springs is delayed until the cradle has completed the greater part of its motion in either direction, so that any slight or partial operation of the cradle effects no change in the switch contacts. A complete movement must take place in one direction or the other before the switch contacts change over.

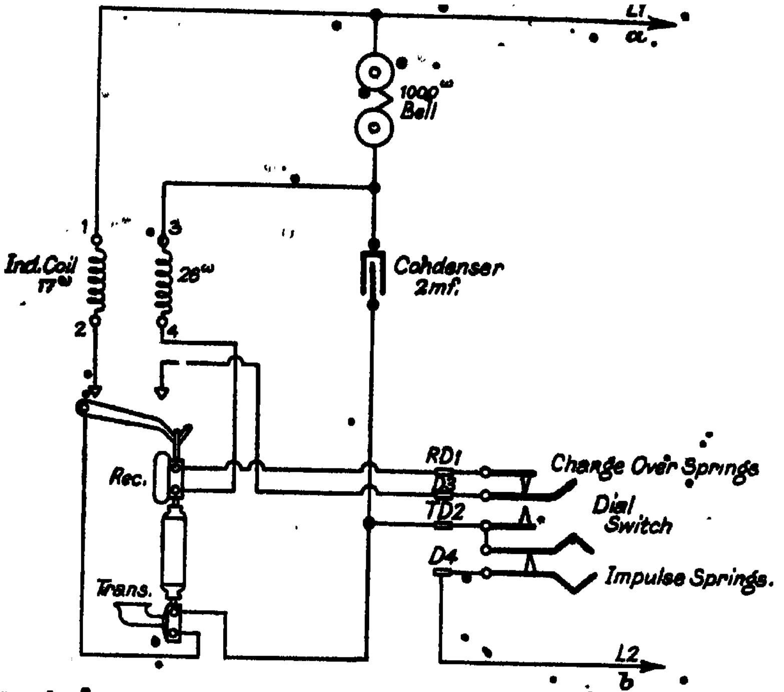


FIG. 135.—CIRCUIT OF WALL-TABLE INSTRUMENT WITH H. M. T. (SIEMENS).

Dial Switch.—This is of improved construction and provided with a patent "minimum pause" feature. It is often alleged as a disadvantage of "step by step" automatic systems that an impatient subscriber can dial so rapidly that a selector, after having received a digit, may not have found a free link before the next digit impulses are sent. Unless some precaution is taken, such cases are in fact liable to occur when dialling all low digits, especially digit 1, and, of course, result in lost or false calls. For reliable operation it is necessary to allow sufficient time for the selectors to hunt between any train of impulses and the succeeding train.

To ensure this, a "minimum pause" device of extreme simplicity has been introduced in this dial switch producing a pause between each digit, unknown to the subscriber and out of his control, and affording a certain safeguard against racing the switches.

The dial switch is the same for both wall and table telephones.

Dial Switch Holder.—This is a ball and socket arrangement which permits the dial switch to be set at the correct angle for dialling when the telephone is used either as a wall instrument or as a table instrument. The alteration is made by releasing a single fixing screw which is retightened after the dial switch has been moved to the required angle. The dial switch need not be removed from the holder in making the change.

When no dial switch is fitted, a suitable cover plate is placed over the aperture.

Circuit.—The circuit is shown diagrammatically in Fig. 137. The circuit is in principle that standardised by the British Post Office for C.B. instruments; but arranged with a hand microtelephone and, when for automatic working, with a dial switch.

When no dial switch is fitted, terminal D1 is strapped to terminal D2 and terminal D3 to terminal D4. The conversion to automatic working is made by simply removing these two straps and fitting the dial switch and cord.

Transmission.—The design of the circuit and the electrical constants of its component parts are such that the instrument is suitable for use and will give transmission equal to the standard in volume and articulation on all C.B. or automatic systems for which the standard instruments referred to in the "Transmission Efficiency" clause below, are suitable.

Each telephone is subjected to the British Post Office standard "Transmission Efficiency" test, which is as follows:—

"Instruments supplied to this specification to be capable, when fitted with a standard receiver, of transmitting commercial speech, equal to that of the Department's standard C.B. wall telephone over a circuit equivalent to 46 miles of 'test cable' (resistance 88 ohms and capacity ·054 microfarad per mile of loop) connected as shown in the diagram and specification referred to in clause 1 of the third schedule to an indenture dated the 2nd of February 1905, between the Postmaster General and the National Telephone Co."

Extension Working.—The standard telephone so far described can be used for simple extension without intercommunication, the extension instruments being wired "in parallel," the main and extension using the same induction coil condenser and bell. This arrangement is, of course, only suitable where the two instruments are close together. Where a bell is necessary to call the extension a slightly modified form is supplied. This differs from the standard only in that the case is pierced in two places (in the front of the telephone on each side of the dial switch) so as to accommodate the keys for calling the extensions. Further, the wiring of the telephone is slightly re-arranged so that the requirements of different systems of extension working can be met with a minimum of interference with the connections. Provision is made for fitting one or two keys, as required, and these keys may be of the plunger or of the lever type, thus providing for many different extension arrangements without the use of apparatus external to the telephone.

When the extension conditions demand generators, additional bells, etc., a second case is provided to accommodate these.

When the telephones are required for non-extension use with the possibility of subsequent conversion to extension working, the instrument is supplied fitted with two small cover plates on the key piercings. These cover plates may be removed and keys added as required.

The standard instrument provides for the fitting of an extension bell.

Section 65

AN IMPULSE EQUALISING DEVICE (A. T. M. CO.)

In automatic systems the calling impulses are distorted and attenuated by the quality of the line, just as the speech vibrations are. Repeaters and other corresponding devices are introduced at intermediate points on trunks to relay or repeat the impulses, so that they are sent forward again in proper shape and at correct intervals.

It sometimes happens that the same repeater or switching device will be used in connection with trunks of different lengths. Fig. 138 shows an arrangement designed to equalise the impulse-current strength so that it is of the same value whether the trunk is long or short, and whereby the dial impulses are maintained practically uniform when transmitted over trunks of varying lengths. In a multi-office system this is a matter of very great importance.

The circuits are numbered as follows :—

1. R′ energises when the receiver is lifted and completes circuits 2 and 1
2. R2 energises if the line switch rests on an idle line.
3. If the line on which the line switch wiper rests is busy, R2 is short-circuited and M2 energises to find an idle line. R2 energises when an idle line is found. R′ de-energises.
4. Calling line made busy over wire to connector terminal.
5. Caller's loop extended to selector-repeater. Impulse relay R5 energises.
6. Guard relay R6 energises.
7. Holding circuit of line switch.

The impulses are now sent and R5 de-energises and re-energises according to the digit value.

8. VM8 energises and steps-up the shaft.
9. Slow R9 energises for the duration of the impulses.
10. Rotary interrupter relay R10 energises.
11. R10 holding circuit. When the first digit is completed R9 de-energises.
12. RM12 energises and steps the wipers to the first set of terminals. Circuit 11 is opened and R10 de-energises. Circuit 12 is opened and RM12 de-energises.
13. If the first line is busy, R10 again energises to step the wipers to the next terminals.
14. If the first line is idle there is no short-circuit of R14 over the test circuit, and R14 energises in series with R10. R10 does not energise. Circuit 8 is open to cut off the vertical magnet VM.
15. R14 holding circuit.
16. The selector-repeater is extended to the connector. R16 and R16′ energise.

16′. Neutralising winding of R31.

17. Guard relay R17 energises.
18. Connector made busy and R14 holding circuit completed. Second digit sent in and R5 de-energises and re-energises.
19. R19. The two windings of this relay neutralise each other. R19 energises and de-energises with R5, and opens and closes circuit 16.
20. R9 (slow) energises for the duration of the impulses, and short-circuits a winding of R16′ and R31.

R16 responds to the impulses of R19. Relays 5 and 19 may have to repeat impulses to a short or a long trunk. R19 therefore operates in a peculiar manner to make the impulses uniform. The two windings of R19 oppose each other. When circuit 19 is closed, R19 energises to close the contact in the B wire. Circuit 10 is then completed through the lower

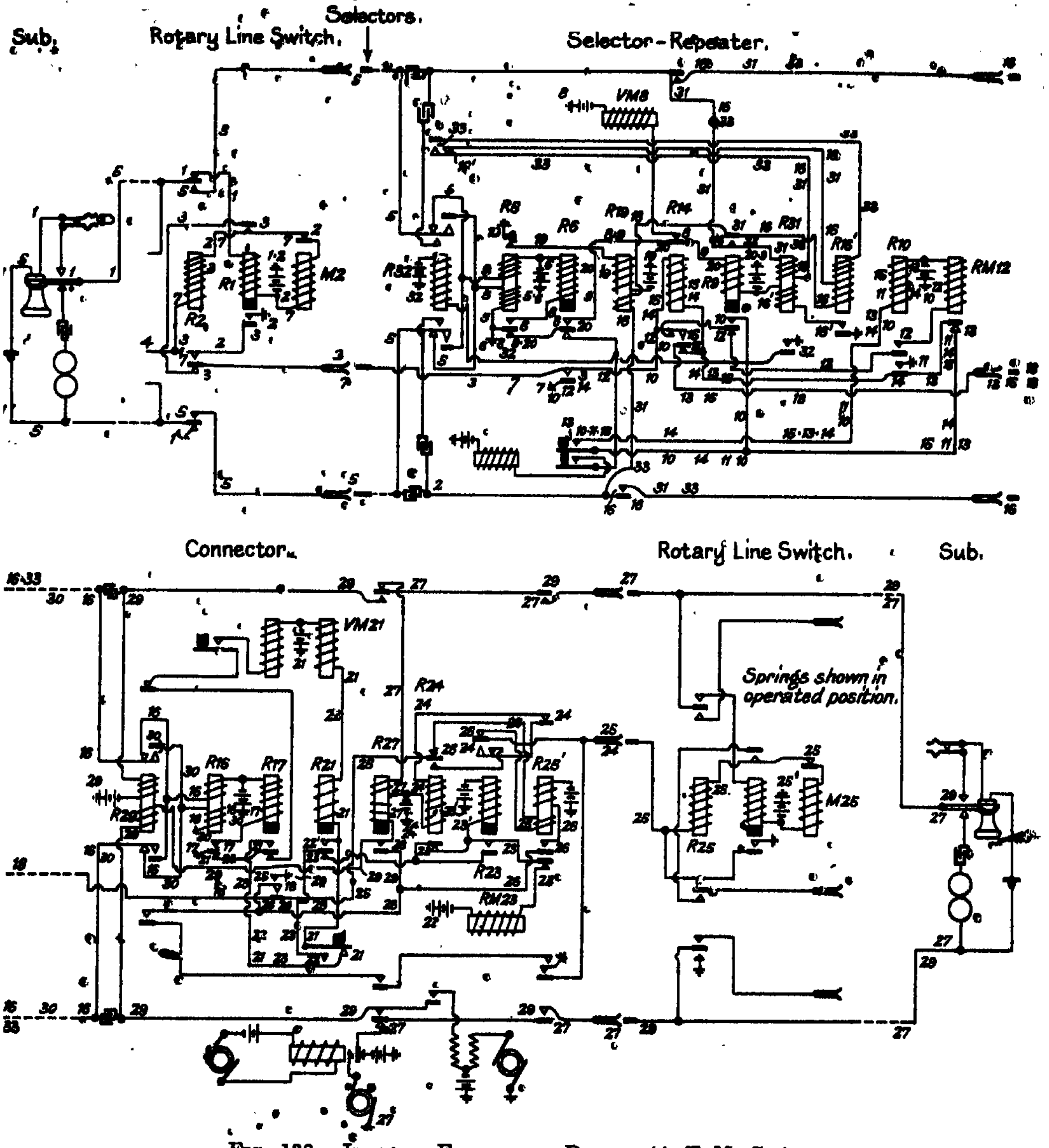


FIG. 138.—IMPULSE EQUALISING DEVICE (A. T. M. Co.).

winding. Now, if the trunk line is short (to relay R16), and therefore of low resistance, a heavy current will flow through the low resistance of R19, so that when circuit 10 is again opened the heavy current will cause R19 to de-energise quickly, so that the impulses are comparatively short. If the trunk is long, and, therefore, of high resistance, the current in circuit 16 will be smaller and R19 will de-energise more slowly and increase the length of the impulse. R19 therefore automatically adjusts itself to the value of the outgoing trunk. The winding in the circuit 19 has more turns, so that the current in the winding in circuit 16 is never strong enough to prevent R19 operating.

21. VM21 energises and steps-up the shaft. R21 energises for the duration of the impulses.

22. New circuit for VM and R21, circuit 21 being opened at off-normal contact on first step. After impulses R21 de-energises and opens circuit 22 at 22′.

Final digit impulses.

23. RM23 rotates wipers. R23 energises for the duration.

24. If the called line is busy R24 will energise over earth on the terminal and busy tone will be given in known manner.

25. If the line is idle, R25 and R25′ will energise.

26. R25′ holding circuit.

27. Ringing circuit. When called-receiver lifted R27 operates.

28. R27 holding circuit.

29. Called subscriber's battery feed and back-bridge relay R29 energises.

30. Connections of R16 are reversed to reverse the battery to the repeater.

31. The currents in R31 now assist each other.

32. R32 energises to reverse battery to calling line.

33. Holding circuit of connector, two windings of R16 in series.

Both receivers are replaced to clear.

Section 66

CONDENSER DEVICE TO REPEAT SENDER IMPULSES TO SWITCHES, LAIDLAW

The permissible speed at which a sending device may be operated is limited by the time required for the positive working of the switching apparatus. For this purpose the make and break periods of the impulse are of unequal duration, the movement of the switch wipers being usually effected during the longer of these periods.

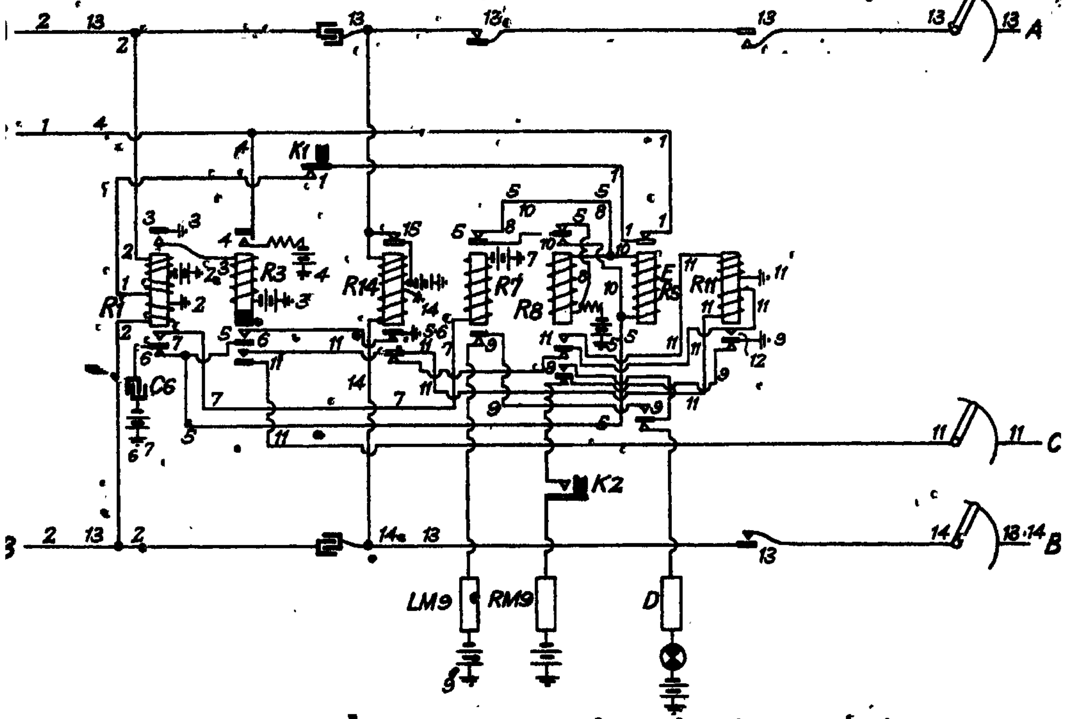


FIG. 139.—A RELAY DEVICE TO REPEAT SENDER IMPULSES TO SWITCHES (E. A. LAIDLAW).

The subscriber's dial-sender is arranged to run at a constant speed and to control mechanically the duration of each complete period, but the relative durations of the make and break periods vary in practice between wide limits by the distortion of the current impulses due to the capacity, inductance, and imperfect insulation of the lines over which the impulses are transmitted and the apparatus associated with the lines.

The actual speed attained in practice is considerably reduced by the effects mentioned. The arrangement shown in the diagram (Fig. 139) is a means to increase the permissible range of speed and the certainty of action of the switching apparatus by means which render its operation independent to a large extent of any adverse conditions of the line.

The arrangement makes use of the property by which a condenser can be charged almost instantaneously, and the energy stored up can be afterwards discharged in the circuit of a relay during a period depending upon the constants of the circuit. The time during which the relay can be energised by the discharge of the condenser, and can consequently retain its armature in an operated condition, is determined by the electric constants of the discharge circuit, and is independent of the distortion of the impulses due to the line conditions, so long as this distortion does not mutilate the impulse to such an extent that the charging circuit of the condenser is never closed.

The current impulses transmitted from the sender are received by a relay, for example, the line relay, the armature of which in one position connects a condenser to a suitable source of electricity, and in another position disconnects it from the source and discharges it through a relay controlling the switching apparatus.

The diagram shows circuits for the control of a first selector with means for retransmitting the impulses, free from distortion, to the other selecting devices used in the setting up of the wanted connection between two subscribers' stations.

The circuit shown is suitable for number impulses in which each impulse comprises a short break and a long make period, the condenser being charged during the break period, and the motor magnet during the make period. In systems in which the impulses comprise long break and short make periods the circuit would be arranged so that the condenser was charged during the make period.

It is assumed that a subscriber has called and that the loop has been extended to the first selector in a known manner.

The circuits are numbered in the order of operation and are as follows :—

1. When the receiver is lifted, relay R′ is energised over the C wire.
2. Circuit over loop.
3. Relay R3 energises, slow to de-energise.
4. New holding circuit for the C wire.
5. Relay R5 energised and opens circuit 1.

First digit impulses.

At the first break of the line by the dial, circuit 2 is opened and relay R de-energises.

6. Condenser C6 in charging circuit.

7. On completion of the impulse, circuit 2 is completed and relay R′ re-energises, and connects the charged condenser to relay R7, which is energised by the discharge of the condenser for an adjustable and predetermined period of time.

8. Short-circuit about relay R8, which is now opened by relay R7. Relay R8 energises in series with relay R5.

When the condenser has been discharged, relay R7 de-energises independently of the condition of circuit 7.

9. Magnet LM9 energises to lift the shaft one step. Shaft contact K′ is then opened.

10. Short-circuit of relay R5, which is thereby made slow to release and therefore remains energised during a train of impulses.

As relay R′ de-energises and re-energises for each impulse, the above action is repeated and the shaft raised to the level required.

Relay R7 is adjusted to hold its armature in the attracted position only for a time sufficient to assure that the armature of relay R5 will be retained during the period in which the relay is short-circuited, and that the armature of magnet LM9 can be fully released and prepared for another step.

When the last impulse of the train has been sent, relay R′ remains energised and relay R5 short-circuited, so that it de-energises and opens circuit 9 to cut off magnet LM9 and join up the rotary magnet RM9.

The wipers then search for an idle trunk in the group.

11. When an idle line is found, relay R11 energises and opens circuit 9 to cut off magnet RM9.

12. The lower winding of relay R11 is connected directly to earth, thereby engaging the called line.

13. The loop is extended to the next selector or connector, and relays corresponding to R′ and R3 are energised.

At the next train of impulses, relay R7 operates as described. Each time relay R7 is energised it opens contact 13′ to repeat the impulses to relay R′ of the selected switch.

14. When the called subscriber answers, relay R14 is energised over the B wire.

15. The short-circuit about the second winding of relay R14 is opened to balance the circuit.

Relay R14 opens circuits 5 and 6 to release relay R8, which prepares the release to be effected in known manner.

DIRECTOR OF [illegible] TRIES
13 JUL 1925
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Section 67

AN IMPULSE CONVERTER (R. A. T. CO.)

In the Relay Automatic Telephone Company's system a device is used which responds to the dial, or other, impulses, and builds up a circuit to energise a relay associated with the called line to complete a connection. This device was for some time called a "selector," but there was confusion between this and the "Strowger" selector. It was then called a "recorder," which appears inapplicable, as it records nothing. I have taken the liberty of naming the device to be described a "converter," because it converts a set of impulses into a circuit that will call a line having that impulse code. In the commercial system a 100-line converter is used, in which a set of inter-acting relays, in response to impulses, first build up the tens and then the units circuit to energise a relay on the called line.

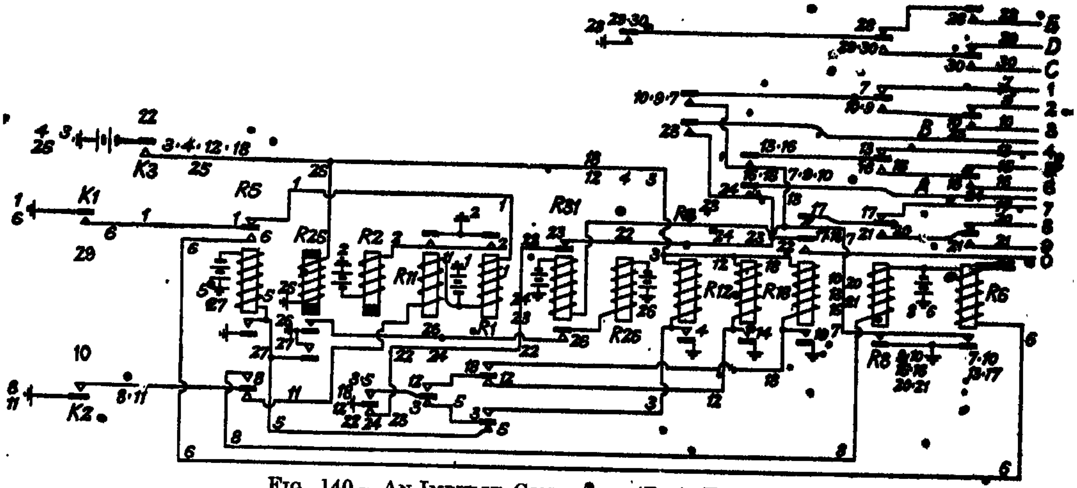

FIG. 140.—AN IMPULSE CONVERTER (R. A. T. Co.).

The impulse converter shown in the diagram (Fig. 140) is for a capacity of ten to fifteen lines, but could probably be developed further. In its present form it might be used for small offices or for selecting groups of trunks. It is interesting as showing the number of lines that may be called by the manipulation of two wires and earth by the emission of two impulse operations only. This requires two wires and earth or three wires.

Contacts K′, K2, and K3 may be closed in any suitable way, as by keys. K′ and K2 are the impulsing contacts. A slow relay de-energises after the emission of one or after two impulses, as the case may be. The contact K3 is closed for a period corresponding to the other contacts, except in the case of the three last circuits (E, D, E), when it is closed for a period prior to the impulses to give time for a slow-to-energise relav (R25) to energise.

Contacts K′ and K2 are in the two wires of the line circuit.

The circuits are numbered as follows :—

Contact K3 is closed in a suitable manner for a time sufficient to allow R25 to energise.

1. R′ energises when K′ is closed.

2. R2 (slow to de-energise) energises.

3. R3 energises.

K′ opened and R′ de-energises but not R2 and R3.

4. R3 holding circuit.

5. R5 energises.

R′ again closed.

6. R6 energised.

7. External apparatus may be energised over line No. 1

If K2 had been closed in a manner similar to K′.

8. R8 energised.

9. External apparatus on line 2 would be energised.

If K′ and K2 had been closed together for the second impulse R6 and R8 would be energised.

10. An energising circuit would be completed over line 3.

11. If K2 closed for the first impulse R11 and R2 energise.

If K′ closes for the second impulse.

12. R12 energises.

13. R12 locking circuit.

K2 held open R5 energises in circuit 5.

14. Energising circuit over line 4.

If K2 closed twice, R12 and R8 energise.

15. Energising circuit over line 5.

If K2 is first closed, then K′ and K2 together, R12, R6, and R8 energise.

16. Energising circuit over line 6.

If K′ and K2 are closed together then K′ closed, R′, R11, and R18 energise.

17. Energising circuit over line 7

18. R18 energises.

19. R18 holding circuit.

If K′ and K2 are closed together, then K2 closed, R8 and R18 energise.

20. Energising circuit over line 8.

If K′ and K2 are closed together twice, R6, R8, and R18 energise.

21. Energising circuit over line 9.

If K′ and K2 are closed together once, and then released, R2 de-energises and R18 energises.

22. Energising circuit over line 0.

If K′ closed once, R2 de-energises and R3 energises.

23. Energising circuit over line B.

If K2 closed once, R2 de-energises and R18 energises.

24. Energising circuit over line A.

25. K3 is closed for a time sufficient to allow R25 to energise.

26. R26 energises.

27. R5 energises.

K′ closed once; R6 energises.

28. Energising circuit over line E.

K2 closed once ; R8 energises.

29. Energising circuit over line D.

K′ and K2 closed together once ; R6 and R8 energise.

30. Energising circuit over line C.

R31 may be introduced to further safeguard circuits C, D, E, and be operated for circuits nes 1 to 9.

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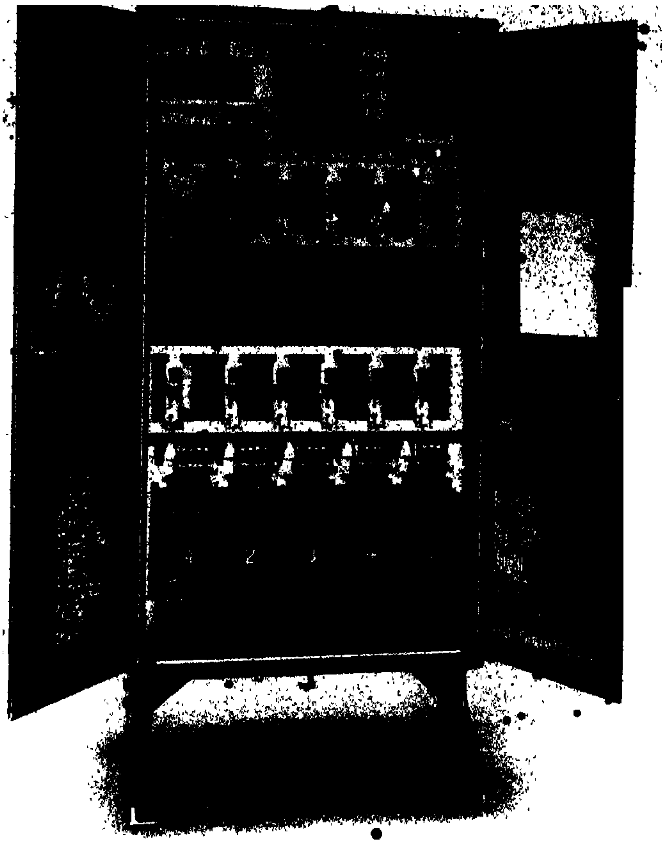

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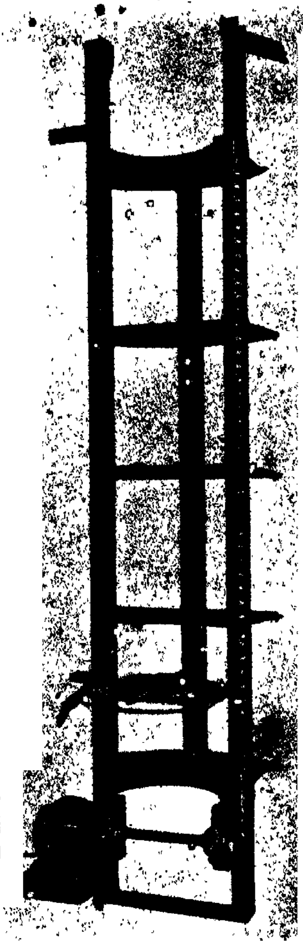

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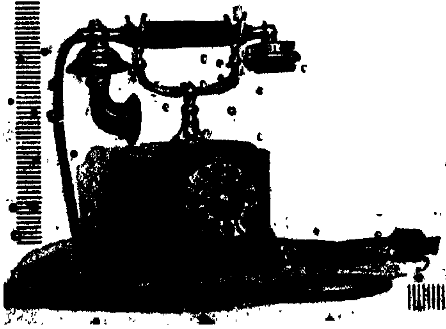

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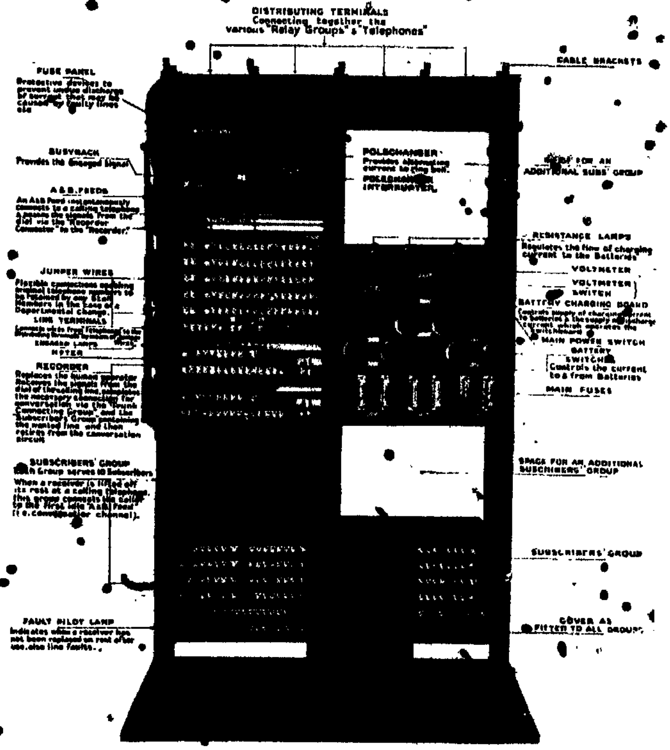
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